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TRANSACTIONS

OF THE

Illinois State Academy of Science

ELEVENTH ANNUAL MEETING

Joliet, Illinois, February 22 and 23, 1918

VOLUME XI

1918

OHIO STATE UNIVERSITY

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EDITED BY
J. L. PRICER AND A: R: CROOK

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OFFICERS AND COMMITTEES FOR 1918-19

President, R. D. Salisbury, University of Chicago, Chicago.
Vice-President, Isabel S. Smith, Illinois College, Jacksonville.
Secretary, J. L. Pricer, State Normal University, Normal.
Treasurer, T. L. Hankinson State Normal School, Charleston.

The Council

The President, Past President, Vice President, Secretary and Treasurer

Publication Committee

The President, the Secretary, and H. J. Van Cleave

Membership Committee

Frank C. Gates, Carthage, Chairman.
John S. Rich, Urbana.
F. D. Barber, Normal.
W. S. Woodburn, Evanston.
W. J. Risley, Decatur.

Committee on an Ecological Survey

Professor S. A. Forbes, University of Illinois, Chairman.
Professor H. C. Cowles, University of Chicago.
Mr. T. L. Hankinson, State Normal School, Charleston.
Dr. V. E. Shelford, University of Illinois.
Mr. H. S. Pepoon, Lake View High School, Chicago.
Dr. Geo. D. Fuller, University of Chicago.
Dr. A. G. Vestal, State Normal School, Charleston.
Dr. Frank C. Gates, Carthage College.

Committee on Conservation of Wild Life

R. E. Wager, State Normal School, DeKalb, Chairman.
H. C. Cowles, University of Chicago.
H. S. Pepoon, Lake View High School, Chicago.
Frank Smith, University of Illinois.

PAST OFFICERS OF THE ACADEMY

1908

President, T. C. CHAMBERLIN, University of Chicago.
Vice-President, HENRY CREW, Northwestern University.
Secretary, A. R. CROOK, State Museum of Natural History.
Treasurer, J. C. HESSLER, James Millikin University.

1909

President, S. A. FORBES, University of Illinois.
Vice-President, JOHN M. COULTER, University of Chicago.
Secretary, A. R. CROOK, State Museum of Natural History.
Treasurer, J. C. HESSLER, James Millikin University.

1910

President, JOHN M. COULTER, University of Chicago.
Vice-President, R. O. GRAHAM, Illinois Wesleyan University.
Secretary, A. R. CROOK, State Museum of Natural History.
Treasurer, J. C. HESSLER, James Millikin University.

1911

President, W. A. NOYES, University of Illinois.
Vice-President, J. C. UDDEN, University of Illinois.
Secretary, FRANK C. BAKER, Chicago Academy of Science.
Treasurer, J. C. HESSLER, James Millikin University.

1912

President, HENRY CREW, Northwestern University.
Vice-President, A. R. CROOK, State Museum of Natural History.
Secretary, OTIS W. CALDWELL, University of Chicago.
Treasurer, J. C. HESSLER, James Millikin University.

1913

President, FRANK W. DEWOLF, State Geological Survey.
Vice-President, H. S. PEPOON, Lake View High School, Chicago.
Secretary, E. N. TRANSEAU, Eastern Illinois Normal School.
Treasurer, J. C. HESSLER, James Millikin University.

1914

President, A. R. CROOK, State Museum, Springfield.
Vice-President, U. S. GRANT, Northwestern University, Evanston.
Secretary, EDGAR N. TRANSEAU, Eastern State Normal School, Charleston.
Treasurer, J. C. HESSLER, James Millikin University.

1915

President, U. S. GRANT, Northwestern University, Evanston.
Vice-President, E. W. WASHBURN, University of Illinois, Urbana.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, H. S. PEPOON, Lake View High School, Chicago.

1916

President, WILLIAM TRELEASE, University of Illinois, Urbana.
Vice-President, H. E. GRIFFITH, Knox College, Galesburg.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, H. S. PEPOON, Lake View High School, Chicago.
Librarian, A. R. CROOK, State Museum, Springfield.

1917

President, J. C. HESSLER, James Millikin University, Decatur.
Vice-President, JAMES H. FERRIS, Joliet.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, T. L. HANKINSON, State Normal School, Charleston.
Librarian, A. R. CROOK, State Museum, Springfield.

MINUTES OF THE ELEVENTH ANNUAL MEETING

The eleventh annual meeting of the Illinois State Academy of Science was called to order, in the Township High School building of Joliet, at 2:00 P. M. Friday, February 22, 1918, by the President of the Academy, Dr. J. C. Hessler.

The minutes of the 1917 annual meeting were read by the Secretary, and approved as read. Reports were made by the Secretary and the Treasurer. Both were accepted on motion, and the latter was referred to the auditing committee. The Secretary's report related how the committee on publications, had acted on what they believed was sure information to the effect that the appropriation of $2,000.00 for the Academy by both houses of the legislature, had received the sanction of the governor, and had contracted for and about completed the publication of Volumes IX and X of the Academy transactions, only to find out later that the governor had really vetoed the measure. This error gave the Academy two perfectly good publications, but unfortunately left it with a debt of something over $1,400.00 While this matter was under discussion, the Secretary read a brief paper which had not been announced in the printed program, and which consisted in the main of a plea to the members to stand by the organization and to help raise the funds necessary to pay the debts, by paying life membership fees and by personal donations. However much or little this paper may have had to do with it, it is true that a splendid spirit pervaded the whole meeting, and as will be shown by the Treasurer's report this year, this spirit continued pretty well thruout the year.

Professor S. A. Forbes gave the annual report for Committee on Ecological Survey, and Dr. A. R. Crook and Professor R. E. Wager gave brief oral reports for the committees on Legislation, and on Conservation of Wild Life, respectively.

Following the reports of officers and committees, Professor H. H. Stoek gave a brief address on the then existing need for the conservation of coal.

Mr. C. H. Smith next presented a list of about 35 names of candidates for membership in the Academy and all were duly elected.

Next, a rather long list of amendments to the Constitution of the Academy were presented, and after some discussion, were adopted as originally proposed. These amendments have been incorporated in the constitution as it is printed in Volume X of the Academy transactions.

Next President Hessler presented to the Academy an invitation to join with the Indiana Academy of Science in a joint meeting some time later in the spring. It was voted to accept the invitation and eighteen members present expressed a desire to attend such a meeting.

Committees were appointed by President Hessler as follows: Committee on Nomination of Officers: Cowles, Noyes, Spicer, Vestal, and Waterman.

Committee on Auditing: Barber, VanCleave, and Lutes.

Committee on Resolutions: Knipp, Pepoon, Wager, and Miss Marshall.

Following this business session, a number of papers of general interest were presented, this concluding the program for the afternoon.

At 7:00 o'clock in the evening the members of the Academy present, together with a goodly number of citizens of Joliet, enjoyed a delightful banquet at the Woodruff Inn.

At 8:00 o'clock, the Academy and a good sized audience of Joliet people again assembled in the high school building and listened to two addresses as follows: One on Science and Patriotism, by President J. C. Hessler, and the other by Professor John M. Coulter, on The Mission of Science in Modern Civilization.

The program for Saturday morning consisted of a Symposium on the general topic, Science and Education. It included seven most excellent papers each of which set forth in most admirable form the claims of some branch of science to a place in general education.

Valuable discussions of the papers were added by Dr. Downing, and Dr. Latham, and others.

At 12:00 o'clock noon, the visiting members of the Academy were delightfully entertained at luncheon by the faculty of the Joliet Township High School.

At the opening of the Saturday afternoon session the committee on Nomination of officers reported the following for the officers for the ensuing year: For President, Professor R. D. Salisbury, Chicago; for Vice-President, Isabel S. Smith, Jacksonville; for Secretary, J. L. Pricer, Normal; for Treasurer, T. L. Hankinson, Charleston; for member of the committee on publications, Dr. H. J. Van Cleave, Urbana; for members of the membership committee, Dr. Frank C. Gates, Carthage, chairman; Dr. John S. Rich, Urbana; Professor F. D. Barber, Normal; Dr. W. S. Woodburn, Evanston; and Professor W. J. Risley, Decatur.

On motion, the Secretary was instructed to cast the ballot and all were declared elected.

It was moved and carried that an amendment to Article VIII of the by-laws be presented at the next meeting, providing that no papers shall be presented by any person other than the author except on vote of the Academy.

It was moved and carried that a committee of five be appointed in the Academy to study the question of the improvement of high school courses in botany, zoology, biology, and physiology, along the lines suggested in the papers of the symposium on Science and Education.

It was moved and carried that the Council of the Academy be given power to act in the matter of bringing about an affiliation of the Academy with the Division of State Museum, of the Department of Registration and Education of the State government.

Following this business session the remaining papers offered by members were presented and discussed and the meeting adjourned at 4:20 P. M.

J. L. PRICER, *Secretary.*

Reports of Officers and Committees

REPORT OF THE SECRETARY

A meeting of the Council of the Academy was held at Urbana on April 7th, 1917, with all members present. The first item of business transacted was the acceptance, by unanimous vote, of the invitation extended to the Academy, by the mayor and other prominent citizens of Joliet, to hold the present meeting in this cty.

Next, the general character of the present program was determined, and the working out of details of the program was left in the hands of the President and Secretary. Several other matters concerning the general policy and welfare of the Academy were discussed, but no definite action was taken on any of them.

On June 29th and again, on July 5th, the Secretary was informed by Dr. A. R. Crook, of the Committee on Legislation, that House Bill No. 853, containing a provision of a thousand dollars a year for the publication and distribution of the Academy Transactions, had been passed by both houses of the legislature and signed by the governor. The second letter from Dr. Crook contained a copy of the bill, with the Academy appropriation set forth plainly in black and white. This convinced the Committee on Publications that the money so much needed by the Academy was at last within reach and they proceeded to arrange for the publication of Volumes IX and X of our Transactions, the manuscripts of which were in our hands.

I should say here that no meeting of the Committee on Publications was held to discuss the policy to be followed under this supposed new order of things. The business was carried on by correspondence and the policy adopted, was in the main, projected by the Secretary and consented to by the other members of the committee. In projecting the policy which was adopted by the committee, I was influenced by a firm belief that there was little liklihood that such aid from the State would not be continued in the future, since it had been granted us this time in a time of great national stress, and under a policy of the strictest economy on the part of the governor.

Since we thus believed that we were assured of $2,000.00 for the biennium, and in that time would have three volumes to publish, I thought it best not to attempt to publish the two volumes already in hand with the $750.00 available for printing the first year, but to borrow a little from the amount available the second year, when only one volume would be published. I also felt that one of the surest ways of guaranteeing State aid in the future was to make the publications of this year as valuable as possible, so as to be able to convince the State authorities that our publications are worthy of the aid granted. Consequently I made a special effort to make the volumes as complete as possible.

Early in August a contract was made with the Miller Printing Company, of Bloomington, for the publication of the two volumes in editions of 2,000 copies each. When the galley proofs were ready they were sent to the contributors for correction, with the statement that the Academy would furnish each contributor with fifty free reprint copies of his article, and that additional copies, in lots of fifty, might be had at a cost of eight cents per page. According to our contract with the printer, the first set of fifty reprints were to cost the Academy thirty cents per page. All contributors, except Dr. Hessler, accepted the offer. Perhaps the offer should now be recalled.

I favored offering the free reprints, first because it would lead to a much wider dissemination of the papers, second because it would attract better papers to our programs, and third because I felt that it was due the contributors.

So matters proceeded until the last week of last December, when Volume IX was about ready for distribution and would soon need to be paid for. Professor Hankinson, the Treasurer, wrote to the Auditor of Public Accounts, asking about the proceedure necessary in order to make payments out of the fund provided by the State. We were all astounded by the reply, which was to the effect that no such fund existed; that the governor had vetoed the Academy item in the bill.

The 2,000 copies of Volume IX were printed when this discovery was made, and Volume X was all up in type. Volume IX consists of 262 pages and will cost, in the 2,000 edition, $660.65. Volume X will consist of 358 pages and in a 2,000

edition would cost $902.10. The printer, however, is willing to cut the edition to 1,000 copies and this will cost $605.70. These costs are exclusive of the cuts for the two volumes, which amounted to $207.25 which has already been paid out of the Academy Treasury. The printing bills in connection with the present program, and for envelopes for mailing out proof, and copies of Volume IX and X, amount to $88.60. The Secretary has a bill for postage on proofs, on copies of Volume IX, and for general correspondence amounting to $30.17. This makes a total of outstanding bills to date, of $1385.12, assuming that Volume X is to be published in a 1,000 copy edition and that the offer of free reprints be recalled. It will cost about $25.00 to mail out copies of Volume X to the members. This will make a total of $1,410.12, which would be needed at the present time to clear us of debt, aside from some small expenses connected with the present meeting.

I had been promised that Volume X would be ready for distribution at this meeting, but heatless Mondays and a few other causes of delay made that impossible, but I am now promised that within a week or ten days I shall be able to send it to the members.

J. L. PRICER, *Secretary.*

REPORT OF THE TREASURER

February 18, 1918.

RECEIPTS

Feb. 23, 1917, Balance on hand	$ 33.81
Feb. 18, 1918, Dues and Initiation fees to date	327.43
Feb. 18, 1918, Life Membership Fees to date	159.00
Feb. 18, 1918, Donations to date	59.00
Total receipts	$579.24

EXPENDITURES

Traveling expenses of officers to date	$ 75.19
Printing, (Including plates for Volumes IX and X)	243.94
Postage, stationery and sundries	37.18
Balance on hand, Feb. 18, 1918	222.93
Total expenditures	$579.24

T. L. HANINSON, *Treasurer.*

REPORT OF ECOLOGICAL COMMITTEE

To the State Academy of Science:

I have first to report the reorganization of the State work heretofore carried on by the State Laboratory of Natural History and the State Entomologist's Office, these being now united under the name of the Natural History Survey of the State as a division of the State Department of Registration and Education. The functions of this Survey are the same as those of the offices which it supersedes, except that they now cover both the botany and the zoology of the state comprehensively, and that the term botany is made to include forestry and plant pathology, in which no state survey work has heretofore been done. The management and staff of the Natural History Survey remain as before, but its work is placed under the control of committees made up of the director of the Department, the chief of the Survey, the vice-president of the University of Illinois, Professor John M. Coulter, of the University of Chicago, and Professor Wm. Trelease, of the University of Illinois. The whole field of the biology of the state is thus covered in all its aspects and bearings, scientific, educational, and economic.

The current work of this Survey during the past year has been largely a study and organization of our recently accumulated chemical and biological data from the Illinois and the Des Plaines rivers and from the Sanitary Canal, brought into comparison with the biological and chemical data obtained before the opening of the canal with a view to an analysis of the effects of that revolutionary event upon biology of the Illinois River system. This work is still in progress, but some of the principal conclusions reached concerning spring and summer conditions can now be stated.

We find that the original sewage load of the upper Illinois has been somewhat more than doubled since 1899* as measured in kilograms of chlorine per second carried by this stream in its downward flow, but that the sewage in the upper river is now much more dilute and very much fresher than in the earlier period. These latter differences are largely due, of

*The Sanitary Canal, it will be remembered, was first opened in January, 1900.

course, to the greater volume and more rapid movement of the stream since Lake Michigan water was introduced into it through the Sanitary Canal.

We also find that the river in its middle course, as at Havana, now carries a larger store of nitrogen in combinations which make it available as food for the river plankton than before 1900, but that a very much larger volume of these food materials now passes on into the Mississippi unused. In other words, the Illinois is now receiving a much larger food supply than it can digest and assimilate within its own course, and these processes are consequently carried forward in the Mississippi to a much greater extent than formerly.

Quite consistently with the foregoing, the successive steps of the self-purification process, evidenced by the appearance of a green plankton and an increasing saturation of the water with dissolved oxygen, occur now much farther down the stream than before 1900. It is important to notice, however, that the biological conditions of the river become normal much farther up-stream than the chemical conditions. In respect to the plankton forms, Averyville (just above Peoria) is now about as La Salle was before 1900; but the former chemical conditions at La Salle are now scarcely reached at Grafton, at the mouth of the river. We also find that the return to normal conditions, both chemical and biological, progresses more slowly down-stream in the bottom sediments of the river than it does in the water over them—that the bottom mud of a given area in the upper river is relatively fouler than the water which flows over it.

This whole subject is very complex and difficult, but Mr. R. E. Richardson, one of the biologists of the Survey, has given his entire time to its study for a little more than a year, and we hope to have a detailed report in print before the summer is over.

Since the last report of the committee, Dr. V. E. Shelford, serving as one of the biologists of the Natural History Survey, has completed and published an investigation of the effects of coal gas on fishes. A preliminary summary of the results of this work was, indeed, printed in the Academy Transactions

for 1916. The equipment of the new vivarium has now been brought into working order, and a series of experiments has been made upon the effects of weather conditions on the rate of development, number of individuals, and general success of several species of insect pests. The work to date shows that in addition to temperature, which is well known to have marked effects, air movement (wind) and humidity have effects which indicate that the relation of weather to insects is more complicated than is commonly supposed. These experiments have been made on cabbage butterflies, chinch-bugs, and pupae of the codling-moth. Those on the last are now being repeated under very carefully controlled conditions, with a view to determining the optimum humidity for each temperature. The chinch-bug, one of the most destructive Illinois pests, is so sensitive to all sorts of conditions, such as kind of food, too little moisture, too high temperature, too rapid air-movement, and the like, that it is extremely difficult to breed it in captivity. The length of time required to enable this insect to pass from the egg to the adult is modified by external conditions to a greater degree than in most other species. These experiments have been carried far enough to show that the chinch-bug can reach the enormous numbers in which it sometimes appears, only under certain very limited conditions. It is hoped that by means of further experiments, these conditions may be more precisely determined than has been possible with field observations alone.

Dr. W. B. McDougall, of the Botanical Department of the University of Illinois, began, during the summer of 1917, a study of the vegetation along the Vermilion River in Vermilion county. The area covered includes bottomland, upland, and much eroded land between. The region is all underlaid with coal, and any study made there necessarily involves important questions concerning the relation of the mining industry, forests, and the practice of agriculture to each other. It is proposed to study the physiographic ecology of the region and at the same time to give as much attention as practicable to the biotic factors involved. It is hoped that a comprehensive report may be made at the end of the season of 1918.

Mr. T. L. Hankinson reports progress in field studies on the fish and associated aquatic forms in the streams about Charleston.

Mr. A. G. Vestal has made minor studies of local inclusions of prairie within forest on south-facing ravine-slopes, and upon invasion of prairie into forested areas in the rights-of-way of railroads. These studies are being reported for the present meeting of the Academy.

An experiment is being started in the planting of an artificial assemblage of prairie plants upon the campus of the Eastern Illinois State Normal School. Some are transplanted and many of the more quickly growing plants are being started from seeds. Favorable opportunities exist and are being used for the study of mixed associations of forest herbs and prairie plants.

Mr. Vestal is preparing to map a township near or at Charleston to show original boundaries between forest and prairie. These boundaries can be made out in many places, and an attempt will be made to map a sample area.

Dr. F. C. Gates reports upon plant collections made by students of Carthage College, leading to a better knowledge of the plant life of Hancock county, and upon the bird work of a class of college students, the product of which has been published as the April (1917) number of the Carthage College Bulletin. Miss Mary A. McMillan has made a comparison of the trees found in cemeteries within the county with those of the natural vegetation, and Mr. J. R. Peters has studied weeds in relation to crops in Hancock county.

Preparations are now being made for a survey of existing forests of the state, in which the members of the Ecological Committee will participate, their traveling expenses being paid by the Natural History Survey. An emergency survey of the plant parasites of important crops has also been undertaken, in cooperation with the U. S. Department of Agriculture, as a piece of war work. All the field agents of the Survey and the members of the Ecological Committee will participate in this inquiry, which is under the general control of Dr. F. L. Stevens, professor of plant pathology in the University of Illinois.

Respectfully submitted.

STEPHEN A. FORBES, *Chairman of Committee.*

Addresses

THE ROLE OF SCIENCE IN MODERN CIVILIZATION

JOHN M. COULTER, UNIVERSITY OF CHICAGO

At the present time science is being called upon as never before to help this country meet a great emergency. This is merely public recognition of the relation between science and the public welfare that has always existed, but has not been realized.

When President Wilson, in 1916, asked the National Academy of Science to appoint a National Research Council, it was because of his conviction that the aid of science was necessary to develop the national resources to their maximum. Ever since that time scientific men have been called to the assistance of the government in increasing numbers. In consequence, the practical men of affairs are beginning to realize the debt of civilization to science, a debt incurred during the times of peace in much more fundamental service than in meeting the emergencies of war. Such men understand now that all they have been able to do in the past, and all hope of future material progress depends upon the results of scientific research. It is high time that the service of science should be more generally understood. not so much that science may be appreciated, but chiefly that it may be enabled to render a still greater service. Now that science has come into public notice in connection with war, it is a fitting time to call attention to its more fundamental service to a civilization at peace.

The service of science expresses itself in three general ways which are not mutually exclusive, but complementary. Opinions may differ as to the relative importance of these three kinds of service, but there is no difference of opinion as to their value. I wish to present them in what I conceive to be the order of their importance.

I. The first service of science is to extend the boundaries of human knowledge. It sets up as its goal to understand nature. We speak of "conquering nature," and of making her a servant

to minister to our needs, but this first service contains no such thought. To such an investigator nature resembles a huge unexplored continent, whose secrets are gradually discovered. Something of the enthusiasm of the original explorers of our great western territory takes possession of him. Every advance into the new territory impresses him with the fact that it is far more extensive than he had dreamed. Every trail is worth following, for it means additional knowledge. Some trails may lead to rich farm lands and gold mines, but in exploration these are only incidents. To understand the new country, all trails must be followed and mapped. The figure has suggested the fact that this service of science is the service of the explorer, the service which makes all exploration worth while. Without it this nation would have had the Alleghanies for its western boundary. Without it nature would have remained a region of mystery, prolific in superstition, and of no service to civilization.

This general exploration of the unknown was once more appreciated than it is now. The original explorations of nature appealed to the wonder instinct of a people to whom the new territory was a revelation; but after the new territory became mapped in its rough outlines, the wonder instinct subsided, and people turned their attention to the farm lands and gold mines; and began to demand that exploration should stand primarily for these things.

Recently, however, the tide has turned and exploration in science is coming into its own again. This is indicated perhaps most significantly by the change of attitude in the scientific work of the government. Using my own subject as an illustration, the Bureau of Plant Industry, under the Department of Agriculture, has recently been adding to its staff scientific explorers. The reason for this has been a realization of the fact that practical application is sterile unless there is a continuous discovery of something to apply. Practice in an old territory is useful, but the discovery of new territory that demands new practice is far more valuable. If it had not been for exploration of territory we would have been farming in New England today instead of in Illinois; and if it had not been for scientific exploration, our practice would have remained that of a century ago.

This attitude of the government is expressing itself also in the developing ideals of agricultural experiment stations, which were formerly merely schools for apprentices, but which are now rapidly becoming schools of science. Furthermore, the general growth of this ideal is being felt in the universities, those notorious hot-beds of pure science, in the increasing attendance of practical students who have discovered that they must know science and must be able to explore.

A remarkable illustration of the incidental advantage that often follows scientific exploration for its own sake may be obtained from the work of the National Research Council. Through that Council a large number of emergency problems have been referred to the various sciences. In the great majority of cases the necessary information has been available because of previous exploration. Even plant taxonomy, often regarded as a subject most remote from the public welfare, has come into prominence as our surest guide to necessary raw products whose ordinary source of supply is no longer available. To know that a given plant yields a certain product is regarded as practical knowledge; but to know the relatives of that plant and their geographical distribution has proved to be far more valuable knowledge.

That scientific exploration is entering upon an advanced stage of its development is shown by the fact that it is proceeding in its methods from analysis to synthesis. Until recently progress in science was marked by an increasing segregation of subjects, so that scientific men were distributed into numerous pigeon holes and labelled. A man in one pigeon hole knew little of the work of his colleague, and cared less. This segregation was immensely useful in the development of the technique of science, by which results are secured, but now we realize the fact that nature is not pigeon holed, but is a great synthesis; and we know that to understand nature, which is to synthesize our results, all of our so-called sciences must focus upon the problems.

This first service of science, therefore, is that of exploring the unknown, and the result upon civilization is the development of the human race into greater intellectual efficiency, and inci-

dentally the extension of civilization by occupying and using new territory.

II. A second service of science is to apply the results of science to human welfare. It sets up as its goal the service of man, and expresses itself in what has been called "applied science," in contrast with "pure science," which is science at the work of exploration. The public has begun to recognize the fact that pure and applied science are not mutually exclusive fields of activity, but complementary, and therefore public support for pure science has been growing, and as a consequence of the practical achievements of pure science in connection with the war, it bids fair to enter upon its own in public estimation and support.

The idea, however, that there are two kinds of science, pure and applied, not only exists in the public mind, but also is reenforced by published statements from colleges and universities. An analysis of this impression that there is such a difference uncovers the fact that pure science is thought to be of no material service to mankind; while applied science has to do with the mechanism of our civilization. The distinction, therefore, is based upon material output. In other words, pure science only *knows* things, while applied science knows how *to do* things. This impression, rather than distinction, has been unfortunate in several ways. The public, as represented by the modern American community, believes in doing things, and therefore pure science seems to them useless. The reaction of this impression upon opportunities for the cultivation of pure science is obvious.

On the other hand, the universities, as represented by their investigators, believe in knowing things, and therefore applied science seems to them to be a waste of investigative energy, and its devotees appear very unscientific; very useful, but not to be acknowledged as belonging to the scientific cult, the cult of explorers. The reaction of this sentiment sometimes has been to avoid the investigation of problems that have an obvious practical application. In recent years, however, the spirit of service has invaded the universities. The university is no longer conceived of as a scholastic cloister, a refuge for the

intellectually impractical, but as an organization whose mission is to serve the public in the largest possible way.

The actual relation between pure and applied science can be discovered by tracing the history of any notable advance in human practice, which is usually regarded as an advance in civilization. It will be found that credit for the material results of science must be shared by those engaged in pure science, those engaged in applied science, and those not trained in science at all. The distinction, therefore, is not in the result but in the intent. In fact, the difference between pure science and applied science in their practical aspects resolves itself into the difference between murder and manslaughter, it lies in the intention. So long as the world gets the practical results of science it is not likely to trouble itself about the intention. In every end result of science that reaches the public there is an inextricable tangle of contributions. Between the source of energy and the point of application there may be much machinery, and perhaps none of it can be eliminated from the final estimate of values, and yet the public is in danger of gazing at the practical electric light and forgetting the impractical power house. In fact, schemes of what is called education in science have been proposed which would instruct in turning on the switch, and say nothing about the power house.

It is becoming obvious also, that all application must have something to apply, and that application only would presently result in sterility. There must be perennial contributions to knowledge, with or without immediately useful intent, that application may possess a wide and fertile field for cultivation.

The conclusion is safe that all science is one; that pure science is often immensely practical; that applied science is often very pure science; and that between the two there is no dividing line. They are like the end members of a long and intergrading series, very distinct in their isolated and extreme expression, but completely connected. If distinction must be expressed in terms where no sharp distinction exists, it may be expressed by the terms fundamental and superficial. They are terms of comparison and admit of every intergrade. In general, a university devoted to research should be interested in

the fundamental things of science, the larger truths, that increase the general perspective of knowledge, and may underlie the possibilities of material progress in many directions. On the other hand, the immediate material needs of the community are to be met by the superficial things of science, the external touch of more fundamental things. The series may move in either direction, but its end members must always hold the same relative positions. The first stimulus may be our need, and a superficial science meets it, but in so doing it may put us on the trail that leads to the fundamental things of science. On the other hand, the fundamentals may be gripped first, and only later find some superficial expression. The series is often attacked first in some intermediate region, and probably most of the research in pure science may be so placed; that is, it is relatively fundamental; but it is also relatively superficial. The real progress of science is away from the superficial, toward the fundamental; and the more fundamental are the results, the more extensive may be their superficial expression.

A notable illustration of this connection between fundamental science and its superficial expression is that given by the study of organic evolution. Before the beginning of the 19th century evolution was a speculation, which was as old as our record of human thought. During the 19th century it came to be based upon observation, and thus became a science, but its appeal was simply to those who wanted to understand nature. At the beginning of the present century it became a subject for experiment, for observation had reached its limit, and it was necessary to know through experiment whether one kind of organism can produce another kind. This experimental work began to uncover the laws of inheritance, or of heredity, as we have come to call it. The discovery of these laws suggested methods of securing practical results in plant-breeding never dreamed of before, and a revolution in agriculture was the result. It is a far cry from speculation concerning evolution to a solution of the problem of food production, but the continuity is unbroken.

It is the proper balance between the two ideals that must be maintained. The physical needs of man, great as they may be, must never obscure the intellectual needs of man; especially as

the trained intellect is the speediest agent in meeting physical needs. On the other hand, the intellectual needs of man, noble as they may be, must never lose sight of the fact that the speediest results are obtained by the enormous increase of experimental work under the pressure of physical necessity.

III. A third service of science is to develop a scientific attitude of mind. It sets up as its goal a more effective citizen, and expresses itself in the results of science in education. It is not necessary for me to consider the relation of the different sciences to education. This will be presented in the program of tomorrow by those who are in a position to know. Each science may hold its own peculiar relation to the needs of the student, as an educated person and a citizen. I wish to consider, however, the contribution of science in general to education, and through education to civilization. Any substitution of practice for scientific training is substitution of manipulation for knowledge, and is not to be regarded as science. The contribution of science to education is the development of a scientific attitude of mind, which means a way of looking at things rather than a way of doing things. The recognition of this factor in education has been shown recently by the numerous calls for men with scientific training; that is, not apprentices who have learned to do something; but students who have learned to understand something, which will enable them to do many things. It is this attitude of mind which has revolutionized modern thought and resulted in a new type of civilization. It has banished superstition as a controlling motive, and is the hope of our further progress.

It is important for teachers that this mental attitude be analyzed and the method of its attainment realized. There is much teaching in the name of science which does not secure it, and for this purpose there is no substitute for science. The scientific attitude of mind is probably nothing more than trained common sense, but a fuller definition will indicate more clearly the significance of this ideal.

In the first place, it is a spirit of inquiry, which recognizes that we are surrounded by a vast body of established beliefs that need a thorough going over to distinguish heirloom rub-

bish from the priceless results of generations of experience. It is also a spirit that demands a close connection between a result and its claimed cause. Failure to develop this spirit provides the soil in which political demagoguery, destructive charlatanism, and religious vagaries flourish like noxious weeds. It is a spirit that keeps one close to the facts. One of the hardest things in my teaching experience has been to check the tendency to use one fact as a starting point for a wild flight of fancy. Such a tendency is corrected somewhat, of course, when facts accumulate, and flight in one direction is checked by a pull in some other direction. Most of us, however, have the tendency, and the majority are so unhampered by facts that flight is free. There seems to be abroad a notion that one may start with a single well attested fact, and by some machinery of logic construct an elaborate system and reach an authentic conclusion, much as the world imagined for more than a century that Cuvier could do if a single bone were furnished him. The result is bad, even though the initial fact has an unclouded title, but it too often happens that great superstructures have been reared upon a fact that is claimed rather than demonstrated.

Facts are like stepping-stones; so long as one can get a reasonably close series of them, he can make some progress in a given direction; but when he steps beyond them he flounders. As one travels away from a fact its significance in any given conclusion becomes more and more attenuated, until presently the vanishing point is reached, like the rays of light from a candle. A fact is really influential only in its own immediate vicinity; but the whole structure of many a system lies in the region beyond the vanishing point.

Such "vain imaginings" are delightfully seductive to many people, whose life and conduct even are shaped by them. I have been amazed at the large developmnt of this phase of emotional insanity, commonly masquerading under the name "subtle thinking." Perhaps the name is expressive enough if it means thinking without any material for thought. An active mind turned in upon itself, without any valuable objective material, seems to react upon itself, resulting in a sort of mental chaos. In short, the scientific spirit is one that makes for

sanity in thought and action, a spirit which is slowly increasing in its influence, but which as yet does not control the majority of citizens. Of course, the methods introduced by science are now being developed in connection with other subjects, but science gives a training peculiar to itself, and it is this contribution which expresses the service I wish to emphasize.

I shall assume that any peculiar result of science in education must be obtained, not through information in reference to the facts of science, but through contact with the materials of science. However valuable information may be, it can hardly be regarded as a substitute for knowledge. Information is always at least second hand; while knowledge is first hand. The real educational significance of personal experience, which is a better name for what we call the laboratory method, is very commonly overlooked, even by teachers of science.

We were first told that science teaches the laboratory method, the inference being that the content of science is of no particular educational advantage of itself, but is merely useful in teaching a valuable method. Of course this method holds no more relation to science than do algebraic symbols to algebra; they both represent merely useful machinery for getting at the real results.

Then we were told that science cultivates the power and habit of observation. Of course it does, but this is not peculiar to training in science, for it belongs to any subject in which the laboratory method is used. Then it was claimed that the study of science trains the power of anaylsis. This is certainly getting the subject upon higher ground, for the power of analysis is of immense practical importance; but to imagine that analysis is the ultimate purpose of science in education is not to go very much further than to say that the ultimate purpose is the laboratory method. The latter is the method, the former is but the first step in its application, and is by no means peculiar to science.

Beyond analysis lies synthesis, and this certainly represents the ultimate purpose of science. The results of our analysis are as barren as a bank of sand until synthesis lays hold of them;

but even synthesis is not peculiar to science. To pass by the incidental and the temporary, and to reach the real and permanent contribution of science to education is to discover that it lies, not in teaching the laboratory method, in developing the power of observation, in cultivating the spirit of analysis, or even in carrying one to the heights of synthesis. It is in the mental attitude demanded in reaching the synthesis. In this regard the demands of science are diametrically opposed to those of the humanities, for example, using this term to express the great region of literature and its allies. The general effect of the humanities in the scheme of education may be summed up in the single word appreciation. They seek to relate the student to what has been said or done by mankind, that his critical sense may be developed and that he may recognize what is best in human thought and action. To recognize what is best involves a standard of comparison. In most cases this standard is derived and conventional; in rare cases it is original and individual; in no case is it founded on the essential nature of things, in absolute truth, for it is likely to shift. It is the artistic, the esthetic, which predominates, not the absolute. The whole process is one of self-injection in order to reach the power of appreciation. If the proper result of the humanities is appreciation, whose processes demand self-injection, the proper and disinctive result of science is a formula, to obtain which there must be rigid self-elimination. Any injection of self into a scientific synthesis vitiates the result. The standard is not a variable and artificial one, developed from the varying tastes of men, but absolute, founded upon eternal truth.

Two such distinct mental attitudes as self-injection and self-elimination are not contradictory, but complementary. The exclusive development of either one must result in a lopsided development. Persistent self-injection tends to mysticism, a confusion of ideals or even vagaries with realities, a prolific source of all irrational beliefs. Persistent self-elimination narrows the vision to a horizon touched by the senses. The two processes and the two results are so distinct and so complementary, that any scheme of education which does not provide for the definite cultivation of both of these attitudes is in constant danger of resulting in mental distortion.

You have now the reason for the statement that the scientific attitude of mind is trained common sense, and also for the claim that this service of science is related to the better equipment of the race for meeting its increasingly complex problems.

To summarize the whole situation: the service of science is, first to understand nature, that the boundaries of human knowledge may be extended, and man may live in an ever-widening perspective; second, to apply this knowledge to the service of man, that his life may be fuller of opportunity; and third, to use the method of science in training man, so that he may solve his problems and not be their victim. Such results suggest that science, through exploration, through practical service, and through education, is to be regarded as the most important factor in developing civilization.

SCIENCE AND PATRIOTISM

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The business world may still adhere, in its formal correspondence, to the beginning of the Christian era as the year 1; the National Government may still date its documents as of such and such a year of the Independence of the United States; but the unconscious, yet none the less real starting point for this generation will be, for many a decade to come, "August of 1914." For in that fateful month and year the whole easy-going nation of us: business man, labor leader, religionist and scientist and all of those who spoke glibly and dreamed idly of the "parliament of man and federation of the world" were pushed up against reality and saw the world as it is, not as we wish it to be. The sensation we had was like that of a friend of mine who parted some leaves along his path through a tropical jungle and looked into the face, not of a rare flower, but of a crouching jaguar. Of all the phases of reality that we saw in those August days none was so rude and abrupt as the bristling, brutal word "Kultur." Since men heard that word, life for us has never been quite the same. It was laughable, if one could laugh when his heart (to misquote the poet Lowell) "was going pittypat, when it wasn't going 'pity the Belgians' ",

to note the way in which the press of our country got to work to define "Kultur." The obvious equivalent was, of course, culture. We all knew something of what that meant, by reputation at least. It meant ease and enjoyment and discernment and appreciation and all that. But as an equivalent for Kultur, culture was always a failure: for Kultur has a boom in it—a Krupp boom, perhaps—that culture lacked.

You will pardon yet another attempt to describe, if not to define "Kultur." There was once a little girl who was studying Geometry and had a great deal of difficulty in understanding the definition of a line. She was told that it was something without breadth or thickness, having only the quality of length. She finally got another conception of a line: the kinetic conception; that is, that a line is a point in motion. In the same way the mathematician thinks of a solid as formed by a plane in motion. Now the American idea of culture has been, not a kinetic, but a static conception of a plane, or a stratum, if you please, of society. Like a plane, it is very, very thin; it can be used for a veneer; it can be slipped in anywhere without taking up any room; two such cultures can easily occupy the same space without seriously interfering with one another. But with Kultur it is different; for Kultur is a culture in motion. It has length and breadth and thickness and its sides are on the move; it generates a material solid; and two such solids cannot occupy the same space at the same time. The question we have been asking ourselves since August of 1914 is whether there is enough force behind the planes of German culture to expand the solid until it fills the earth.

There is not the slightest doubt that the kinetic idea of culture is the one put forth by our great enemy overseas. She felt for decades that her civilization was superior to all others; hadn't all the world said so? Why then shouldn't all the world be eager to embrace its beneficent, all-inclusive, all-pervasive sway? The vision of what this powerful Kultur may mean, how it may obliterate all man's other efforts at civilization, how it may engulf the aspiration of mankind for life and liberty and individual culture, these things we have seen with our eyes until we have grown sick at heart. Louvain, the Lusitania, Scarborough; these are but points—incidents—in

the advancing plane of Kultur; if we are to believe the Teuton, they and others like them are justifiable and right. But the world remains unconvinced and asks: "Has all the struggle of the ages been only for the purpose of bringing us at last to a material civilization that has in it all the elements of moral barbarism?"

There were three great bonds that men had hoped would hold the Western world together and that should have operated against the break of 1914. The first of these was the internationalization of labor. How big and mighty this seemed to us just before the war! How well we remember the threatened strike at Paris against the war declaration itself. How well we remember, too, the boasting of the labor leaders of Western Europe that they had the power to hold the working classes together against the efforts of chancellors and premiers to bring about a general war. With what assurance public speakers told us of the impossibility of world strife because the world's labor interests would not produce the sinews of war. On that thin, negatve reed men leaned for support, then wondered that it failed them. Yet every one who wished might have known that for years German factories were making munitions one month out of every year and were at all times ready to go upon a complete war basis. What reason had labor to expect that the munitions it helped to make for the Prussian war lords would never be used by those lords for their own sinister purpose? Even as war broke out, it seems to us, German labor might have saved the day had it felt the pull of international gravitation. But instead it felt the stronger, closer, centripetal whirl of the national Kultur. Like Lee in '61 it turned aside from the greater, newer union to respond to the old appeal of a native state. Does America now believe, or must she still be taught, that we may not depend, for a long time yet, upon the negative weapon of an international strike to keep us out of war?

A second great bond that men hoped would hold the nations together is their common religion. Nothing has so indicated the growth of real Christianity as the enlarging meaning of that exclamation of Peter's; "Of a truth I perceive that God is no respector of persons (or nations)." And, conversely, noth-

ing so fully convinces us of the thinness of Teutonic culture as its gross, brazen appeal to its tribal Gods. It makes the heart ache to read of the studied, cold-blooded indorsement of all the crimes of Pan-Germanism by a servile Teutonic ministry and religious press. All that Christianity stood for as the permeating, unifying force of mankind was brushed aside by the military lord. The appeal to the higher sentiments of men, like the appeal to the unification of labor, was felt to be only another bond that made for the solidarity of a conquering nation and the impenetrability of its Kultur.

Internationalism in labor we may reject as leading to the state of the Bolsheviki, but the universality of the religion under which all men are brothers must survive; it must not be swallowed up in the conception of any national Kultur. To be sure, when the war is over, and when men in Teutonia may again speak out, we shall learn that in this modern Israel, as in that of the days of Elijah, there will be found 7,000 men who have not bowed the knee to Baal, nor kissed his golden image. But they are gone as effective agents in this war. So far as we can see, only the Social Democrat speaks out, and he less and less clearly, as fraternization with the Bolsheviki grows less and less useful to the purposes of the military party.

A third agency, which we had thought would make impossible such an estrangement as came in 1914, was that of the intellectual fraternity of our Western world, including the brotherhood of the men of science. We can see why religious leaders might forget the universal faith, when we remember that in all the contending countries, men's aspirations have become embodied in historic churches, rites and creeds. But none of these existed in Science. Science, we were told, is too young, too practical and too intellectual to be swayed by historic statecraft and by outgrown governmental systems. Men even thought a bit archaic and in poor taste the stalwart patriotism of Pasteur, who because his beloved Strasbourg was alienated in 1871, refused to hold or to accept any honors which the Teutons sought to confer upon him for his priceless discoveries on the origin of disease. Yet in spite of this feeling, when the coup of 1914 was to be sprung, we have no record of any attempt by German science to stay the hand of the militarists

by an appeal to the brotherhood of science and learning, as a reason for peace. We still think with horror of the reported arguments used by German scholars, including her foremost scientists, in favor of, not against the war. With glib tongues, they talked of manifest destiny and the right of might. Yet these were the men who had met with us in our conferences, at whose feet some of us had learned science and history and criticism, who had vowed the unity of learning as a permanent force for peace and brotherhood and universal understanding. Was any apostasy so great as that of the scientist who knew the futility of force, and yet throttled with brutal phrases the faith he had once embraced? Or were any lips so false as those of the man of learning who spoke not the word of truth, but only the false testimony that radiated from Potsdam? Too late we learned that German science, like German labor and religion, was only a phase of the great national Kultur and only useful to its countrymen as it aided, abetted and defended that Kultur in its stroke for world mastery.

There is no great need to stress the fact that this war, as no war that came before it, is a war of science against science. Even above the cry; "To your tents, O Americans," was heard the call, "To your laboratories, O, Scientists." For the submarine was transformed all at once from a scientific toy into the wasp of the sea; the dirty coal tar became in an instant a precious possession, for it became the raw material of munitions. From submarine detectors and depth bombs and gas masks to substitutes for rubber and platinum, from the manufacture of optical glass to the preparation of aniline dyes and antiseptics, everywhere the scientist has been asked to give his knowledge and his methods to the national defense. We need only call the roll of the research laboratories of the country, commercial as well as educational, to realize how many are in the service and what a war of science it is. We are arrayed against a nation of scientists, and brain is fighting against brain even more than arm against arm. We had toyed with the airplane; the Germans, the scientific as well as the military aggressors, soon made our efforts look like child's play. Speed and range and stability took on a new aspect, for they now meant not the plaudits or shudders of gaping crowds at Long

Beach, but success or defeat on the Western Front. Gases which the chemists had worked with cautiously in his laboratory, fully protected by fume chambers and ventilating systems, were liberated on the battle field in such volumes that they transformed whole companies of "first-class fighting men" into gasping, writhing wretches. How sorely has the science of the allies been tried to meet such infernal devices of destruction. Of the consecration with which our American men of science have given themselves to the defense of our democracy we can speak only with the highest praise. May their every effort be crowned with success!

But what of the days after the war? Shall we again seek to save the world with the prattle of a culture that has no body in it, that is disconnected from reality, or shall we give ourselves, as a people, to a Kultur that has three dimensions. Is an American Kultur possible that can satisfy the everyday needs of men and yet be strong enough to compel respect? In the hour when danger threatens, shall we have the means of defense organized, or shall we go back to our desire for individual, uncontrolled selfishness? Shall the relation of German science to our own be restored as an autocracy or as a real democracy of science, founded on reciprocal respect for achievement? We may respect German science, but it is more important that we respect our own, which is another way of saying that America must have a real science as the basis of its national life. America has too long been the humble imitator, feeding to German science the "pap" of a flattery that has raised it to its present status of the foe of mankind. It is not too much to ask that we have a science that will not merely engage in private research, but also in the organization of business, that will take not simply a subservient attitude toward constituted authority, but the role of the ruler himself.

The progress of the war is showing us more and more clearly that America has been all along the target at which the Teuton plans have been aiming. These plans included an acquiescent United States, so that there might be a subservient South America. A United States which flattered itself that the seas kept off the danger of an invasion, while it hid securely behind the British fleet. A United States that deluded itself

into believing that it could raise armies over night and that it need only blow the tocsin and its sons would spring forth fully armed and in battle array. A nation that loved peace and thought that it would be left alone forever to pursue its solitary way. A nation also that has had no conception of the price men must pay for a worthy peace or an honorable "place in the sun." A happy-go-lucky nation that has been too busy picking golden apples to care much for the slow, painstaking methods of science. When the whole story of the war is written, we may see that the fatal error of German strategy (an error based upon its own narrow view of things) was the failure to launch its first attack, not on little Belgium, but on the impotent United States. No alliance would have compelled any European power to raise a hand to help us. With that score settled, the starvation of England would have been easy. If we have another war, Germany will not make this mistake again.

Even now, before the American army has been made fully ready, certain interests are talking of a quick return to the easy, irresponsible days before the war. Loud-mouthed patriots are already crying that they want to eat, buy, and sell what they want, when they want it, in whatever quantity they want it, without regard to the future of democracy in America or anywhere else. Even those of us who are more far-sighted are not yet through with the delusion that everlasting peace can be had for asking. Even while we are talking of such a peace, the German is talking of the next war. There is no hope of permanent peace for this country until we have developed an effective, unified, organized Kultur for ourselves. As a nation having a body of ideals, habits, achievements that can be respected we shall make ourselves powerful for peace. We can then accomplish something for world democracy. As a nation unorganized and uncontrolled, we cannot possibly save ourselves, to say nothing of making a real contribution to the peace of the world. As there is a Kultur formed to destroy nationalities, so there must be a Kultur dedicated to saving them; as there is a Kultur planned to sow discord, so there must be one just as efficient and far more powerful, planned deliberately to promote peace and understanding. As the one is bound to make itself feared, the other must make itself respected and

loved. The call is for the consistent development of an American Kultur, of a unification of all our aims, ideals, methods, with the purposive intent of producing a democracy as efficient as any autocracy, yet with space for the growth of individual initiative.

Can we organize our democracy for an "offensive" peace? To develop such a democracy we need at least two things; first, the knowledge, and second, the "will to live" as a free people. This brings me to the point of this paper. We need *scientific knowledge* in America. We need it most, not as a knowledge of the past, but of the present, for the rules of the past help us very little today. We need to know our world as it is today. We need that knowledge as a basis of our common life, of our national culture, of our world plans. The idea of working together for a great future purpose is almost unknown to us; must such a possibility exist only for an autocracy? When conservation is called for, we as a people need to know science, or we cannot conserve wisely and cheerfully. When we wish to engage in a new manufacturing enterprise we need to have science, not that it may stand as a wage servant at our elbow and merely register our will, but as the forerunner and pioneer to blaze the trail. As we cannot raise armies over night, so we cannot make our people scientific by wishing them to be so. Scientific knowledge must not simply be diffused among our people, but *ingrained into* our people, so that they can act as an intelligent unit toward a common purpose. The conviction of this need rises paramount to every other; to achieve this end should be the aim of our national policies, the goal of our popular education. Science is not analyzing bugs, or making oxygen, or measuring the distance of the stars, or guessing the age of a trilobite. Greater than these individual products of science, are the methods of science. To ascertain the facts, large and small; to eliminate the non-essential ones; to draw conclusions; to realize the limitations of these conclusions, yet to derive a working philosophy from them; and to determine upon a line of action based upon the facts and the conclusions —these are the ways of science. It will need two generations, at least, of scientific, devoted, patriotic thinking to make us a scientific nation. We cannot learn the principles of science by

lectures when we are grown up, or in the frenzied effort to drive off an enemy who is knocking at our doors. We must play with the means of science as toys in our childhood, must grow up with them, watching them expand as we grow, until they change from toy to playmate, and from playmate to counselor and friend.

We believe American civilization has in it something worth living for and worth dying for, but the living and the dying will alike be in vain if the experience of this war does not teach us the need of consistent scientific solidarity, and push us rapidly into it. Instead of praying for the extension in length and breadth of an idealistic culture, that cannot be realized short of the millennium, let us work as well as pray for a three-dimensional American culture; a Kultur in action. It is well to have the clouds of idealism on which the setting sun may spread the rainbow of hope, but it is not well for present-day men to dwell in the clouds. The ways of science bring us down from the clouds to the actual world in which we and our children must live. Today, the greatest science in the world is linked with the greatest autocracy. Is it to continue so? Science as the handmaid of autocracy may give us a fetish, a superstition, like the "Ich und Gott" cult of the Hohenzollerns; democracy and science will give us *faith*. Have we the "will to live" strong enough within us so that we will subject ourselves to self-denial and self-control for the future good, or is this power of foresight and preparation to remain only in the hands of an autocracy? On her answer to this question hangs the future of America, if not the destiny of the world.

This paper was prepared between the birthday anniversaries of Washington and Lincoln. Never, we believe, have the ideals of these two great Americans meant so much to us as this year. Each of them, we now see clearly, stood like a great rock of the ages between the clamor of the unharnassed idealism on the one hand, and of the gross materialism on the other hand. As we think of their lofty ideals and unselfish patriotism, we also think of their sturdy common sense. For, when you come down to it, this is true science, as it is also enlightened patriotism: *trained common sense* as applied to our world, our country, and to ourselves.

Symposium on Science and Education

THE STUDY OF ZOOLOGY AS A FACTOR IN SOCIAL AND ECONOMIC PROGRESS

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One of the real functions of the high school should be the training of men and women to live. In the secondary schools a large percentage of our population find their training and mental equipment for life. A realization of this state of affairs is bringing about a complete reorganization of the high school curriculum. Fortunately, most people have ceased to consider the primary function of the high school that of preparation for college. The modern trend of vocational education is a manifestation of the extreme point of view in this reorganization. No longer is any subject or group of subjects retained in the curriculum because of some hypothetical cultural value. Utilitarian values are constantly being more stressed. This, with the addition of new subjects to the curriculum, necessarily leads to a sort of competition between subjects. Values are constantly being weighed one against another with the result that many subjects are on their way toward elimination.

Few administrators stop to ask the question if the basis for rejection of any subject is the intrinsic value of the subject *per se* or rather a valuation which has become attached to the subject because of unfortunate conditions and circumstances entirely foreign to the subject but usually associated with it, I believe in the case of zoology in the high schools it can be shown that the materials selected for study and the methods of presentation are responsible for the decline, where such has existed, rather than any intrinsic weakness in the fundamental subject matter as a factor in directing human activity.

A decade or two ago men like Spencer, Huxley, and Forbes convinced the educational world concerning the values of biology with the result that the study of biology was given a considerable impetus and prestige as a subject of instruction in the schools. At that time the number of subjects offered in the high school was relatively small. Competition between subjects for a place in the curriculum had scarcely begun. Biology

secured entrance to the list of studies through the demonstration of the fact that the study of it contributed utilitarian, intellectual, aesthetic or emotional, and moral values to the education of the student. With the increase in our scope of knowledge and the development of new sciences there are now numerous courses offered in the secondary schools all of which contribute to the intellectual, the aesthetic, and the moral or ethical phases of life. Consequently the final struggle for supremecy, or in some cases existence, is to be fought out along the lines of relative contribution of direct practical value in human life.

The past generation has brought forth few educators in the field of zoology. Tremendous progress has been made in the addition of new facts to the bulk of zoological knowledge, but unfortunately no successful effort has been made by the leaders of this science to meet the popular demand for emphasis upon the practical values in teaching. Zoology as taught in the high schools is still chiefly that of the older morphological type in spite of the fact that the more recent advances in the science have frequently possessed more strictly practical sides. This failure to appreciate the necessity of incorporating the practical applications of zoology into the course of the secondary schools is due in large measure to the feeling that the value of zoology had been given full recognition upon its adoption following the efforts of the educators mentioned in the last paragraph. As a consequence of these combined factors no significant advance has been made toward the production of a text-book which would incorporate zoological materials of such importance to social progress as to demand general dissemination.

The prime object of a high school course is not the training of zoologists. In fact any attempt at correlation with later work in university or college course might interfere with accomplishing the very object of such a course, namely that of equipping the individual with a fund of knowledge concerning and attitude toward living organisms and his relations to them. That attempted correlation between high school and college courses has in the past failed is evidenced by the general feeling among university teachers that students who have

had work in high school zoology are but little, if any, better prepared for the intensive courses in the university than are those who have never had such previous training.

Elementary work in a university course of zoology usually takes up the morphology of a series of types as a foundation upon which the study of the higher branches of the science may be built in later courses. Students coming from the secondary schools with a smattering of morphology, superficial, to be sure, but leaving them with the idea that they know the structure of animals, enter their university work with the handicap of self-complacency. At least in some instances this is due to the selection and preparation of the high school teachers of zoology. Frequently persons are required to teach zoology when their preparation consists in nothing more than an elementary course in a university or normal school. The lack of appreciation of the subject and of the problems involved in the teaching of students of high school age permits such a teacher to attempt, with very few modifications, a repetition of the course which he had in college. The result is the cultivation of an abhorence for zoology on the part of the students. Administrators are naturally inclined to attribute this result to weakness in the subject itself for the chances are that the teacher has been a success in teaching subjects for which he has been more thoroughly trained. On every hand there seems to be ample justification for a sharp differentiation between high school and university courses in zoology. Whatever line this differentiation may take it must be kept in mind that there are facts and principles in the science of zoology an understanding of which are vital to the interests of the individual and of society. The dissemination of these must find a place in the program of our secondary schools.

Many teachers have laid especial emphasis upon the value of the study of science as a training in approaching the problems of life and reaching valid conclusions through a grounding in the application of the methods of science. The whole question of the transfer of training is much in dispute but we are led to believe that not much is carried over directly except in case of rather closely related fields. For this reason the study of zoology offers opportunities unique among the sciences because

of the possibilities of direct transfer of methods and content to the problems of man himself. The study of the structure, habits, functions, economic relations, reactions to stimuli, carried out in the field and laboratory upon various animals finds direct application of methods in the study of man himself. The origin and meaning of sex, relations of individuals within a community, degeneracy as an adaptation to conditions of life, are all purely zoological problems capable of direct transfer in the study of the identical problems concerning the human animal. Not all these things can find full explanation in a high school course in zoology, but the student may there be started to thinking along the right lines and to that extent his whole attitude toward life may be modified.

Let us look for a while at some of the problems of every day life, an approach to which can be best made through a properly organized course in zoology for high school pupils. As indicated in an earlier part of this paper practically no one questions the intellectual, the moral, and the aesthetic values of zoology as a subject of instruction. On the other hand these values may well be assumed to be associated in varying degrees with all subjects of instruction. As far as these alone are concerned, one subject probably serves as well as another for training students of high school age. There are, however, phases of zoological knowledge which hold peculiar values for the individual and for society. Were these to cease being matters of common knowledge among so-called educated peoples much of social and economic progress would be retarded. Conversely any agency tending toward the wider dissemination of such knowledge is distinctly opening the way to the solution of many of our economic and social problems.

No one questions the value to mankind of the knowledge of animals in their relations to disease, and the numerous problems associated with this phase of zoology. These have been cited so often that it seems hardly worth while to more than mention a few specific examples. A few generations ago a scourge like typhoid fever was looked upon as a problem which was to be solved by the members of the medical profession. Today it has in addition assumed a distinctly social significance. Little can be done in any community toward the

prevention of a disease like typhoid without the education of all persons in that community in the reasons for exterminating the fly, based upon a study of the structure and habits of that animal. This in turn demands some knowledge of the life history of the fly, for effective measures toward extermination all presuppose such knowledge. Studies of this sort give to the individual more than the training in powers of observation and reasoning which frequently are considered the goal of zoological training. The pupil is not only given possession of facts which, put into practice, make him a better citizen, but at the same time he is given a distinct advantage over those who are not possessed of this kind of zoological knowledge.

Few persons lead an existence which does not at some time or other bring them into contact with insect pests of household, crops, domestic animals, or of man himself. All effective means of combating and controlling such pests find their solution in the feeding habits and life history of the insects. Simple problems in development and in the structure of the mouth parts of the insects, which are correlated directly with the feeding habits, are studies which may be taken up to good advantage by the average student of high school age.

The enactment of fish and game laws, and laws for the protection of song birds all have as their aim, directly or indirectly, the conservation of the resources of our country. Persistent violators of these laws are, on the whole, the ignorant classes of society for whom the claims of personal liberty are stronger than the demands of social obligation. Bird protection laws would have much greater effect if more people had definite knowledge of the economic importance of our birds in holding insect pests of fruit, grains, and other crops in check. Game laws would cease to be looked upon as infringements upon personal rights if greater numbers of our citizens were informed upon the breeding habits of our game animals and understood the severity of the struggle for existence among such animals as population becomes denser over the entire continent. State and federal officials would find not only support in enforcing existing laws but demands for more effective legislation if the reasons underlying such laws were more fully understood. This would unquestionably be the case if more

general knowledge of such matters were given in our public schools. The final success of the United States in constructing the Panama Canal has often been heralded as more of a biological than of an engineering accomplishment. Other nations starting the task failed, not because of insufficient knowledge of the engineering problems involved but because of the lack of appreciation of the biological phases of the problems of sanitation and transmission of disase. Huge accomplishments of this kind, if they were numerous enough, would convince the most skeptical persons of the values in applied zoology, for the most of us are influenced by the spectacular. However, it may be asserted without fear of contradiction that extension to all persons of fundamental knowledge concerning animals as agencies in disease with means of controlling such relations would stand for more, economically, to the nation than any number of spectacular achievements such as the one just mentioned.

It is difficult, if not impossible, to place a correct monetary estimate upon human life yet the most conservative of figures show that the economic loss to the people of the United States through what are termed preventable diseases is appalling. Many of these diseases do not involve animals other than man directly, so it may be claimed that a knowledge of zoology has no bearing in coping with them. But on the other hand the study of zoology in its relations to problems of sanitation and medicine furnishes a point of departure from which these topics may be reached in dealing with high school classes. The instance of hookworm in its bearing upon the economic problems of the South finds direct application at this point. A few years ago no one would have guessed that a small intestinal parasite could have produced such pronounced direct effect upon the economic status of a community as have been demonstrated in the case of the hookworm. Thousands of non-producing individuals throughout the South constitute an incipient reserve to our economic situation awaiting the application of zoological knowledge and establishment of sanitary conditions to transform them from physical and mental abnormalities into productive citizens. Outside agencies, such as the establishing of commissions for the extermination of such a

pest, are effective but their influence cannot be equal to that of a general dissemination of knowledge concerning such animals through a well organized course in zoology.

The savage goes to the medicine man for a charm and an incantation to keep off disease. To by far too large a percentage of the civilized world vaccination, administration of antitoxins, and similar preventive measures of the modern physician are regarded with a supersition differing from that of the savage only in degree. Our whole system of modern medicine is destined to be built more and more upon the foundation of the development of immunity and preventive medicine. It is not sufficient for the welfare of society that men and women in our colleges be trained in the general methods of the preparation of sera, antitoxins, vaccines and the like, for they constitute by far too small a percentage of our total population. The pity is that some knowledge of these intensely interesting and vital relations of man to other animals in the prevention and control of disease cannot be given to all classes of society. If future generations are to be prepared for the reception of the advances which are bound to come in the practice of preventive medicine, it is essential that the general public be educated along these lines. Otherwise advance in this line would suffer the same fate as that accorded the practice of vaccination when it was first introduced into this country. History is replete with the records of social and economic revolutions which, once started, have failed because of the fact that the people had not been prepared to accept them. The logical place for the preparation of the general public for the advances in medicine which have been outlined above rests with our high schools and more specifically in connection with the courses in zoology.

Our public press in the past few years has conducted several campaigns against the quacks operating under the disguise of the medical profession. Occasionally we read sensational articles upon the apprehension of a few miscreants and the exposure of their methods of operation. The vast majority of the tribe remains unmolested and stands as a stigma in most communities. Most thinking people if asked for an explanation of why these conditions exist are free to confess that ignorance rests at the bottom of the whole system. It is not, however, the

ignorance of illiteracy for many of the victims are of what we might call the educated class. The ignorance that plays into the hands of such imposters is the ignorance of the human body which prudish persons frequently mistake for a type of chastity. Any person ignorant of the structure of the human body and its normal functions is just as much an obstacle in the path of social and economic advances of a community or nation as is the quack who preys upon such ignorance.

Turning now to some of the other phases of zoology which might be emphasized as of direct human value, the much discussed problems of heredity and those of sociology growing out of the operations of heredity can have little significance to the individual who is not acquainted with the fundamental concepts of the animal cell and its structure. Not that I claim an extensive study of the cell by students of this age is desirable or even possible, but the concept of the cell as the unit of bodily structure with at least a brief knowledge of the reproduction of the cell and the functions of the chromosomes as bearers of the determiners of hereditary qualities constitute a type of knowledge possession of which is essential to right thinking and to the abandoning of superstition regarding the genesis of life and the hereditary relation of parent and offspring.

A full realization of man's place in the universe can come only after a careful study of man's relations to other animals. In its entirety, this is a problem too deep for the adolescent mind to grasp. However, it has been well said that primitive man *felt* rather than knew his relationship with other animals. In much the same way the child with his inherent interest in animals offers a foundation already prepared upon which to build a knowledge of those animals and a beginning of an understanding of his relations to other organic beings. Here is a field where the study of zoology alone can direct the primitive instincts of kinship between man and other forms of life toward the formulation of a rational concept of man's place in the universe.

Some practical knowledge of organic evolution must be behind every move in the progress of man. The facts of evolu-

tion may be recorded on the printed page but some facts standing alone have little true significance to the individual who has not had some first hand knowledge of the structure of a graded series of animal forms. Further, in the study of the varieties of domesticated animals we find material which is able to impress the high school student with the idea of plasticity of animal form and the responses of the organism to the factors of evolution even though they are here manipulated to great extent by man. It is but a step from this conclusion to a realization that these same laws of evolution are operative upon the human being. True, not all high school students would grasp the significance of such a conclusion; not all would be able to take this final step; but the chances are that many would sooner or later be able to think the problem through for themselves and arrive at the conclusion that since man is subject to these same laws of change, man and his creations must participate in the endless march of time. If his progress is not upward it must be in the opposite direction for the progressive change of evolution works equally in either direction. Such a conception is an absolute essential for a social or economic leader of men. For that reason it seems imperative that the background against which such concepts may be formed should be presented to as many of the future leaders as possible. The high school is none to early to begin training along such lines.

THE NEED OF A MORE GENERAL KNOWLEDGE OF AND TRAINING IN BOTANY

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Recent developments in the field of botany have been so remarkable that botanists may justly feel proud of the knowledge, the great material prosperity, and the improved living conditions made available, by the contributions of their particular science.

The subdivisions of the mother science have become so vigorous and have penetrated so far into their respective fields that it is impossible for the members of any one group to be thoroughly cognizant of the achievements of the others. There is, however, a common ground on which all botanists may meet. There is likewise a stock of knowledge which must be not only the possession of botanists, but which must become the inheritance of the average citizen if botany is to fulfill the important mission allotted to it by nature. It is chiefly in the interest of botanical education that I wish to speak.

Genetics as we know it at present in its application to plants youngest member of the botanical family. Since its rebirth less than two decades ago, it has held the spotlight of the scientific stage, and the workers have done much to deserve the attention they have received. Definite methods of procedure have been formulated by which cultivated plants may be modified almost to suit the fancy of the producer. By an intelligent manipulation of the normal reproductive processes of plants, new varieties may be produced, desirable characters accentuated and objectionable qualities removed. Yet genetics, mendelian inheritance, and eugenics are terms which have but little vital significance to the vast majority of college graduates, while to the great rank and file of citizens educated in the public school they are meaningless symbols.

All botanists know that phytopathology has passed from the pioneer stage. Its importance to all phases of plant production is now so well established that colleges and universities every-

where have departments wholly devoted to this branch of botany. Conclusive evidence to justify the formation and maintenance of these new departments at public expense is to be found in the results obtained by the corps of active practitioners associated with every experiment station. But to what extent has the great body of knowledge accumulated by the experts become effective in the practices of the average man engaged in growing plants? My observations in this particular field have been somewhat extensive, ranging from the large commercial nurseries to the back woods farmer. It has been found that the producer who treats his seed wheat for smut or his potatoes for scab, or who in any way modifies his practice to prevent the infection of his crops or to control the spread of contagious diseases is the very rare exception. The resultant losses are measured in hundreds of millions of dollars.

In bacteriology the contrast between the valuable knowledge extant and the portion functioning among the people is greater than in any other field of botany. And since many of the edicts of the bacteriologists are laws of health nonconformance to them through ignorance is all the more disastrous. City ordinances calculated to protect public health are for the most part dead letter laws. No law can be inforced against an indifferent or antagonistic public opinion. Ignorance when not antagonistic is usually characterized by indifference. Instead of our public schools being places where specific and effective instruction is given on the nature and control of contagious diseases, they are more often places where contagious diseases are disseminated. It is truly pathetic to hear well meaning parents rejoice because Willie got the whooping-cough or Johnie the mumps, measles, chicken pox, scarlet fever or what not, while he is young. Their theory is, and to our disgrace it is the prevailing theory among the masses, that people must have these diseases and therefore the sooner it is over with the better for all concerned.

It would be ludicrous if it were not so serious to witness the attempts to prevent infection when the information goes out from the health officials that the city water supply is contaminated. City folks are not the only nor even the worst offenders against the laws of sanitation so well known to the botanists.

Down on the farm where everything is supposed to be so pure, fresh and healthful, we more often find filth resulting from garbage undisposed of, open privies, and other sources, so that one is continuously exposed to typhoid, hookworm, and diarrhea through the well known channels of infection.

These conditions it seems to me are directly chargeable to the lack of an educational policy intended specifically to overcome them.

The agriculturists are doing more and succeeding better in disseminating the facts which we hope are destined to transform farming from an empirical practice to a scientific procedure.

As the result of state and national aid the agricultural experts have gone directly to the adult population and with much tact and persistency have demanded a hearing. No such inclusive campaign has ever before been attempted in American education. The results, in so far as the results of an educational campaign can be judged, have justified the effort and the expenditure of public money. There is, however, much remaining to be done. There are legions of farmers living contentedly in their sins. They plant their crops by the moon, operate on their stock according to the signs of the zodiac, and carry buckeyes to ward off disease. Many of these individuals have been in contact with the truth, but they have passed the formative period of their lives and their habits have become fixed. They may even assent intellectually to the teachings of the experts, but they have not the power to adjust themselves to the new methods. They go calmly on doing as their fathers did while the average yield of crops thruout the country is only from one-third to one-half what it would be if the average farmer knew and applied the available knowledge on plant production. As propaganda the course which has been pursued by the agriculturists has produced wonderful results, but as a fixed educational policy it has many elements of weakness. The greatest good has come, not from the regeneration of the adult population, but from the number of young people who have been influenced to enter the schools and take up a systematic and thorough study of agricultural science.

I have included this statement on the conditions in agriculture because as Dr. Gager recently said, "Most botanists have never been able to shake off the superstition that somehow or other the successful growing of crops is in part at least a botanical problem."

Suppose we turn our attention from applied botany very briefly to the pure science side of the subject without which there could be no applied science worthy of the name. Suppose we were to select some of the big and vital things which have been done recently in plant physiology or morphology, in taxonomy or in ecology, in cytology or evolution, and go before the public to find out what is known in these fields of plant science. We should learn not only that the so-called educated public knows nothing of the facts, but also that the individuals are extremely scarce who know that the field of botanical endeavor has become so large as to include any such subdivision of subject matter.

The facts which I am endeavoring to emphasize are: (1) that there is a large stock of extremely valuable knowledge in the botanical storehouse. Knowledge which has as many points of contact with the lives and practices of the people who compose the average community as can be established by any of the fundamental sciences. It is knowledge which applies directly to sanitation and maintenance of health, to the production and preservation of foods, and to increased efficiency wherever there is involved an intelligent control over plant life or plant products. (2) Just as obvious as the preceding and to those of us interested in public education equal to it in importance is the fact that there is but a very small portion of this knowledge that is being used by the people to whom it is most applicable and by whom the funds have been contributed which has made it available. Through the lack of judicious advertising and efficient salesmanship there is but little public dmeand for our goods and our most valuable stock is lying stored in the libraries unused.

Live contact has not been made between the research laboratory and the public mind. As a result the current which should transport the new knowledge to all the people and which

should ever carry a fresh and vigorous supply of new workers back to the laboratories is not functioning effectively in either direction. The public is not receiving just returns on its investment and it is only natural that the condition should be met by indifference and the withdrawal of support.

The U. S. Commissioner of Education tells us that the number of high school students taking botany decreased 45% between 1910 and 1915, and that less than 8% of the *total* enrollment studied the subject.

Botanists must decide if it is desirable for the present movement to continue. It means that in the near future botany will be studied only in the colleges and the universities, and that knowledge of plant life from the scientific point of view will gradually disappear from the people who receive their entire education in the elementary and the secondary schools. If this is considered desirable then the present course which is a sort of intellectual isolation is the correct one to pursue.

Any one who knows the subject matter of botany and who is interested in public education will look upon such a result as a calamity both to the science and to education.

The attempted solutions which have been presented recently under the names of Civic Biology—Elementary Agriculture, General Science, and other popular names have for the most part been unsatisfactory to the botanists. We feel as if we were trying under a camouflage of popular phrases, to teach our students a little botany without them knowing it. A rose by any other name may be as sweet, but the botany which has been offered under these assumed names has in most cases been so dilute that it is well nigh valueless. It perpetuates none of the valuable history of our science, meets the present needs only in the most superficial way, neither does it have any elements of promise in it for the future.

There is, after all, a good deal in a name and it is very unfortunate that botany has become a synonym of uselessness in the public mind. The name seems to stimulate about the same round of emotions in the average individual that the term Nature Study creates among the scientists, except, perhaps,

that the latter are a little more violent. I believe that the good name of botany can and will be cleared of the unjust indictment of being useless. I also believe that science will soon form a part of the elementary school course, but I doubt if it can go in under the name of Nature Study.

The work done by the advocates of general science has, I believe, been done in good faith and it has served at least one excellent purpose. It has put the case squarely before us in a way that demands immediate attention.

It is not a simple problem. Many factors have contributed to the condition so tersely expressed in the report of the Commissioner of Education. It seems to me that the discussions of Dr. Gager and Prof. Jordan before the sections of Botany and of Agriculture respectively of the American Association for the Advancement of Science point us in the right direction. What these men have said I believe is in perfect harmony with what Prof. John M. Coulter has been preaching in season and out of season for the past five years or more. The apparent harmony of thought and purpose coming from what in the recent past have been considered rival camps is evidence that progress is being made. I believe that the time should come and I have faith that it will come, and that soon, when the agricultural courses both in the secondary schools and in the colleges will require a preliminary knowledge of botany. The agriculturalists need it and the botanists can do the job. *When agreement can be reached on what the content of such a course should be a big step will have been made toward the solution of our problem.*

I do not believe, however, that botanical courses in the secondary school should exist entirely or even primarily, as a preliminary to agriculture or horticulture. There are too many students who by the very nature of the case cannot continue in that direction and botany can be made to serve them in a more effective way.

I would like to see the courses in botany prepared for the high schools and for beginning work in college so that the points of application to the lives and interests of every one would be so numerous and so evident that there would be no

question as to why they should be required of all, no matter what occupation might be chosen in the future.

In the administration of these elementary courses I would remove the handicap of extra hours which has been arbitrarily imposed on high school science and which is one of the chief causes of its unpopularity with students. I believe that five hours a week under a good science teacher will contribute as much to the education of a high school boy or girl or of a college freshman as an equal numbers of hours spent in any other subject even though two or four of these hours are spent in the laboratory. The extra hour requirements in the elective sciences have caused the courses to be shunted into almost inaccessible places on the schedule and to be handicapped in numerous other ways. Botany as well as the other sciences would be greatly benefited if more men educated in science would sacrifice their personal interests and seek administrative position.

The best time for the training of a botanist to begin is while he is still at his mother's knee, and the more agencies which can be made to contribute to the desired end the better. Much effort may well be spent in general appeal and instruction by the press and from the stage and platform, but in the last analysis the regularly organized educational institutions will have to be held responsible for the job. Surely there is no place in the public school system where in this so-called scientific age the teaching of science should be neglected.

There is a rich fund of material related to the knowledge of, and control over, plant life which is admirably suited for the needs of all the children in the elementary school. The big reason why Nature Study has been a failure up to the present time is that the scientists have not given it the attention it deserves. Adverse criticisms have been and are abundant, but constructive cooperation has been almost lacking.

There should be a direct and definite course of science teaching which should proceed in regular sequence through the elementary school, and the high school into the university. I would direct no one into such a course simply because it led into the university, but because the lives of those who traveled in that direction would be enriched and enlightened every step

of the way. It should make no difference whether an individual went but a short distance along the route or whether the entire journey was completed. He should be given direct and immediate values for the time and effort spent.

Other sciences have established the connection between the fundamentals of their subject matter and the daily lives of the people without material loss in scientific value, and I believe that botany will not longer lag behind in the process.

THE NEED OF A MORE GENERAL KNOWLEDGE OF AND TRAINING IN CHEMISTRY

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Before we can discuss properly the place of chemistry or of any other science in a scheme of education we must have a basis in some true philosophy of education and back of that must be a sane philosophy of life. Very many of the present tendencies in High School education seem to imply that its primary purpose is to develop men and women who are money making and money spending machines and that life consists chiefly of the externals, food and drink, and clothing and recreation and material resources. The poet Tagore gives a quite different view —to him the ideal of life is not acquisiton, but *realization* and our greatest teacher has said, "The Kingdom of God is within you." For three and a half years of terrible war, Germany has been fighting because the masses of her people have believed that she is surrounded by hostile nations which threatened to destroy her civilization and because her leaders believe, with some show of justification, that their civilization is the best in the world and that it is their duty to impose it on others. Our allies have been fighting that the principles of justice and humanity may not perish from the earth and they are slowly coming to see that international cooperation and mutual helpfulness are better than selfish national aggrandizement. On both sides the nations of the world are demonstrating that they are willing to sacrifice a million lives and the material accumulations of a generation for ideals which are of greater value than life tself.

The dominant purpose of our education should be, therefore, to prepare our pupils for a rich and varied intellectual and spiritual experience in life. To secure such an end we should not have a series of disconnected science courses filled with interesting information which the pupil can safely forget as soon as he has passed the semester examination, but a graded course in science running through four years arranged in such a manner that each part rests upon that which precedes. The natural sequence might be physiology, botany, zoology, physics, chemistry. I place chemistry at the end because it is better adapted than any other science to bring, with its own special contribution, a correlation of all the scientific knowledge which precedes it. It would be well to give an examination at the end which should cover in a comprehensive manner the work of the four years. The older education secured such a consecutive, graded course by the study of Latin. Scientific studies will never satisfactorily replace Latin in genuine educational value until we secure some such graded work as I have outlined. I think that some of our smaller schools, with a limited program, follow a better pedagogical model than the large, strong schools with their hodge-podge of electives, often administered without demanding a proper sequence of subjects.

In the presentation of chemistry or of any other scientific subject the attempt should not be made to give merely interesting information about a series of disconnected facts but rather to develop scientific habits of thought and the ability to understand clearly those simple, fundamental principles which are our most valuable heritage from the past. Above all the pupil should learn that these principles are not to be taken on authority but are logically connected with facts easily understood, some of which he can reproduce for himself. While the laboratory work should doubtless begin with experiments which illustrate the facts of general inorganic chemistry, qualitative analysis, if properly taught is better adapted than any other subject with which I am acquainted for the development of accurate, scientific methods of thinking.

The opinion is all too common that no study is "practical" which does not directly minister to the student's ability as a money-getter. If we accept the ideal which I have put before

you—that our purpose should be to prepare the student for a rich and varied experience in life by suitable intellectual training in habits of accurate thought—courses which give some real knowledge of the science are certainly more practical than courses which give a great variety of interesting but disconnected information.

In vocational courses, however, the information important for the vocation which the student is preparing to follow finds its proper place. The ideal, as it seems to me, would be that each pupil before leaving school should have some vocational training. If he is to leave at the close of the eighth grade, at least a part of his work should have a direct bearing on his future vocation. If he is to go out into life from the high school he should be trained in school for some definite vocation. The same is true of the University if his education is to close there. But the amount of time given to training for a vocation should never be so great as to crowd out the more important training for life and for citizenship.

PHYSICS IS A FACTOR IN A LIBERAL EDUCATION

Fred D. Barber, State Normal University

As an instructor in physics in a Normal School and Teachers' College, I conceive it to be my chief duty to give such instruction in physics as will enable my students most successfully to teach that subject in our public schools. With this end in view I feel it my duty to study constantly: First, the prevailing curricula of our public schools, especially our high school; Second, the service which our public schools can render the people of this state and nation; Third, the choice of subject matter and the methods which will best accomplish the desired results. In this paper I shall, therefore, briefly indicate some conclusions bearing upon these points so far as physics is concerned.

In thus confining my discussion to these points I beg you not to suppose that I am unmindful of the importance of research in physics. Without the fruits of research in physics nearly all lines of engineering, as well as the application of physical principles to many trades, to agriculture, even to housekeeping

in the modern home, in fact to nearly all occupations of life must to greater or lesser extent stagnate. To the research worker in physics we must ever look for inspiration and for the further mastery of the physical forces which makes progress along many lines of life's activities possible. All honor to the research worker in physics and his co-workers in allied sciences for the knowledge of the physical world and physical forces which is making possible the engineering achievements in the great world conflict which is upon us. If the United States and her allies shall finally triumph in this greatest of all human struggles, that of democracy in resisting the tyranny of autocracy, and we all believe that we will so triumph, the victory will largely be due to the achievements of research and the inventive genius of the Anglo Saxon in utilizing those discoveries in our defense. And if at the end of this gigantic struggle this war-wrecked earth shall be able again to gather its wasted power and forces together and again become a peaceful and comfortable abiding place for mankind, with humming industries and thriving commerce, with food in abundance, with the common comforts of life and a reasonable measure of life's pleasures available to the masses, the achievement will largely be due to man's mastery over the physical forces about him. We shall ever look to the research worker and his revelations for the knowledge which gives man an ever increasing supremacy over his environment.

It seems certain, however, that the field of research in physics is in little or no danger of neglect. Capital and gigantic industrial organizations hold forth mighty inducements for research work in physics. Moreover, our great universities, many of which are liberally supported from state treasuries, gather together many of our best prepared research workers and place at their disposal abundant means for the prosecution of their work. Even though I thought it desirable, but which I think is quite unnecessary, yet no word I could utter would in the slightest degree stimulate or accelerate research in physics.

It is, therefore, not to the problem of research in physics but to the problem of the dissemination of the fruits of research among the masses to which I wish to call your attention. This, it seems to me, is the great need of the hour. If the value and

significance of scientific research is not revealed to and appreciated by the rising generation there will certainly be fewer research workers in the next generation. Also, if the masses come to regard science instruction in our public schools as of little importance, much of the service which research in science might render humanity will be lost. It is my purpose to point out the fact that at the present moment there is great danger that such an attitude towards science may become prevalent not only among the masses but even that the authorities in charge of our public schools may also assume that attitude. This Academy of Science cannot afford to be indifferent regarding the position in which science finds itself today in our public schools. The attitude of the nation towards science in the years to come will largely be determined by the attitude of our public schools towards science tomorrow.

THE DECLINE OF PHYSICS IN OUR PUBLIC HIGH SCHOOLS

During the past twenty years there has been a constant decline in the *percentage of students* in our public high schools who enroll in physics classes. In the United States as a whole, according to the reports of the Commissioner of Education, the percentages of high school students who enrolled in physics has declined from 19.04 per cent. in 1900 to 14.23 per cent. in 1915, a decline in fifteen years of 25 per cent. In Illinois, during the same fifteen years, the percentage enrollment has declined form 17.40 per cent. to 12.73 per cent., a decline of nearly 27 per cent. While this decline in percentage enrollment has been vastly less marked in physics than it has been in some of the other high school science subjects it has been sufficiently great to cause us to pause and seriously reflect upon its cause and its significance. It should be noted that this decline in the percentage of high school students who enroll in physics has taken place during a period when the control of our physical environment was rapidly increasing as a factor in our national development. That the decline in percentage enrollment other high-school science subjects is still greater is no consolation to the physicist, but rather an added source of alarm. That the decline in percentage enrollment in physics was only between 3 per cent. and 4 per cent, during the five years from 1910 to 1915 affords some consolation. One can not

resist the temptation of asking, however, whether it is probable that the decline in percentage enrollment and apparent appreciation of physics as a high-school subject is about to cease. Can we reasonably expect at the present time to see a reaction set in and to see physics soon regain its former position as a high-school subject? I have been asked to speak of physics only, but what I say concerning physics as a high-school subject today could be reuttered in much stronger terms regarding other high-school sciences.

I regard it as most timely that this Academy has at this meeting turned its attention to a consideration of science as a factor in our common school educational system. A widespread spirit of unrest and a prevalent dissatisfaction with our school curricula coupled with a strong popular demand for efficiency and conservation in all life's activities are making new demands upon common school education. Nor, in my judgment, will this demand cease with the close of our present struggle for the maintenance of our national freedom. On the contrary, I believe, that the period of reorganization which will follow the close of the war, if the perpetuity of democratic institutions is guaranteed, will demand that our system of public school education shall be thoroughly reorganized with a view of making it more efficient and of greater value to the masses.

THE SMITH–HUGHES ACT

The demand for greater efficiency on the part of our public schools, so far as it relates to the training of the masses of young people who will of necessity, in a large measure, become the producers of the next generation, is clearly shown by the passage by Congress of the Smith-Hughes Bill. By the terms of this act many millions of dollars will be available as federal aid for the promotion of strictly vocational training to be given within our public high schools. This act seeks to encourage the public high school to provide technical training for boys in agriculture and the industrial trades and for the girls in domestic economy. Moreover, this technical training is to begin with the entrance of the pupil into the high school, that is, at the age of about fourteen.

No one can today safely predict to what extent this act by the federal government will have upon the public high schools of Illinois and of the nation. Nothing is more certain, however, than the fact that when the federal government holds out a substantial bonus to the high school which will conform to the curriculum prescribed many high schools will conform and the act will be a large factor in the reshaping of high-school curricula in the immediate future.

To appreciate the possible effect of the Smith-Hughes Act upon science in the high school we need to recall some of its provisions. In order to receive federal aid, as I understand the law, every student in the class must devote one-half of his time to strictly vocational studies, the announced purpose of which is strictly the mastery of some industrial trade, or of agriculture, or of home economics; one-fourth of his time may be devoted to closely allied subjects, such as "applied mathematics" or "applied science"; the remaining one-fourth of the pupil's time may be devoted to what are commonly called culture studies. Detailed statements regarding the conditions under which federal aid may be secured are given in the Educational Press Bulletin, No. 124, issued by the State Department of Public Instruction for February and several bulletins issued by the Federal Government.

My only purpose in referring thus briefly to the provisions of the Smith-Hughes Act is to point out the fact that in order to enjoy federal aid the curriculum of the high school, or at least the portion of it which will receive federal aid must be intensely practical. For instance, there is no place provided for cultural science; the science taught must be applied science and have a direct bearing upon vocation chosen. Listen to some of the terms used to describe the character of the science which may be taught: "Prerequisite science", "agronomy", "soil physics", "soil fertility", "animal husbandry", "horticulture", "general science", "applied science", "household physics", "household chemistry", "science essential to competency in the trade or industry which the pupil is preparing to enter". To be sure, the teachers of these courses are required to have training in "related science work such as botany, zoology, chemistry, physics, geology, and mathematics" or as stated in another

place "trade mathematics, trade science, and trade drawing from the standpoint of methods of teaching and teachable content of the trades".

In this statement we have a view of the outlook for high-school science under the provisions of the Smith-Hughes Act. This law as I understand it has the approval of Governor Lowden and of the Department of Public Instruction. Three weeks ago today the Schoolmasters' Club of Illinois was in session at Decatur. As is well known that organization is representative of the school administrative forces of the state. The topic under discussion at both sessions was the Smith-Hughes Act. Its provisions were explained by those who will have its administration in charge. Not a single superintendent present raised his voice to ask whether it is to be the chief function of the public school to give technical training to boys in agriculture and the industrial trades and to girls in domestic economy. On the contrary, to all appearances, it was a scramble on the part of superintendents to learn the exact conditions with which their schools must comply in order that they may share in the distribution of federal funds.

I have long felt that the physics taught in our public high schools has not been well adapted to the needs of the masses. I have long felt that the decline in the percentage of students enrolled in physics was largely due to that fact. From long experience with students coming from our public high schools I speak with positive certainty when I say that physics as usually taught in the high school is both distasteful and uninteresting to a majority of high-school students, especially the girls. It does not appeal to them as worth the effort required to secure the passing grade. It has been, to a large extent, a misfit in the curriculum if it is the purpose of the public school to develop the boy or girl by natural and psychological instruction into men and women who shall appreciate science and shall be able to apply its principles to their own environment. I have long felt that not only physics but all high-school science needs reorganization. If high-school science is to be saved, in my judgment it must be reorganized and adapted more closely to the immediate appreciation and the ultimate needs of the masses. But it also seems to me that the present tendencies

in public school education, if those tendencies are truly represented by the shifting enrollment in high-school subjects and by the provisions of the Smith-Hughes Act, are based upon a misconception of the real immediate appreciation and the ultimate needs of the masses.

To me it is unbelievable that the primary function of the public high school is to start our boys and girls at the age of fourteen upon a strictly vocational training. I can not bring myself to believe that boys and girls of that age are ready for any kind of specialization in education. I believe that at least the first two years of high-school training should be devoted chiefly to the acquisiton of knowledge concerning their social, economic and natural environment. If democracy is to survive is it not evident that to the largest possible extent a common pabulum of environmental understanding is essential? The very hope of democracy rests upon the possession by the masses of a common pabulum of understanding. Surely we are not ready to concede that the capacity to earn ones living is a sufficient qualification to assure good citizenship in a free democracy; the possession of superior skill in a certain trade is no guarantee of good citizenship. I cannot believe that the American people are ready to cast aside the long cherished conviction that general education, general enlightenment is the foundation and bulwark of real democracy.

If narrow vocational education of the type indicated by the provisions of the Smith-Hughes Act shall become the prevailing type of our public school education there will practically be no place in the high-school curriculum for physics or for any other special science. The cultural element of science, the historical element of science, the general enlightenment of science—all these elements of a scientific education must go. The common pabulum of knowledge concerning our natural and physical environment must go. The Spencerian idea of science as a foundation for all solid and substantial education must go. Social solidarity will go. Society will tend more strongly towards stratification for we shall then be turning out from our high schools a body of specialized wage earners lacking social conscience and social coherence. Can democracy survive such a condition?

I believe that a violent reaction is bound to come against this extreme type of vocational education if it is ever accepted for trial by the American people. But I also believe that the present inclination to accept for a trial this extreme type of vocational education is a well-merited rebuke, at least so far as physics is concerned, for the kind of science instruction we have been dealing out to our high-school students. We shall have our rebuke, I fear, in good measure. May we profit by it but at the same time I trust that we may never agree that the narrow, scanty, purely mercinary training in science, a training intended merely to meet the demands of a specific trade, is an adequate training in science for the coming citzenshp of America. Such a training in science can no more prepare the masses for citizenship in a democracy than did the abstract, so-called logical training in science, which we have indulged in so largely during the past quarter of a century, prepare the masses for earning a living.

Somewhere between these two extremes must lie the happy mean. The high-school course in physics almost universally offered in the past has consisted of some two hundred or three hundred physical principles, abstractly stated and inadequately illustrated. Many of those principles have no essential relation to the daily life of the pupil. The laboratory work has generally consisted of blind and often unsuccessful attempts to manipulate with manual dexterity certain apparatus the like of which was never seen outside of the laboratory. The hundreds of set problems have usually been equally remote from the pupil's life experiences. The physics possible under the provisions of the Smith-Hughes Act will be found in limited quantities in the course in general science and possibly in some additional cases where physical principles are clearly required for an understanding of some process in a trade or occupation. No opportunity will be offered for the study of physics for the purpose of giving the student an understanding of or a mastery over his physical environment.

I deem it quite unnecessary that any argument be made before this body to show the necessity of disseminating as widely as possible knowledge concerning the fundamental principles of physics. If any one of the sciences is more fundamental than

the other sciences, if any one has more universal application to human welfare than the other sciences, that science is universally acknowledged to be physics. A fair knowledge of the fundamental facts of physics is important to the farmer, to the industrial trade worker, and to the housewife in the modern home but is no less important as part of the equipment of the citizen for national, state and municipal government is nowadays largely a matter of applied science. I conceive it to be a part of the work of every high school to give something like an adequate training, not only in physics, but also in all the fundamental sciences to all the pupils in that high school.

Somehow, in some manner, we must so modify our science instruction so that it will appeal to school authorities as being of vital importance; science must be made to appeal to the pupils much more strongly than it appeals to them today. Only in this way can we hope to check the declining percentage enrollment in the sciences in our public high schools.

Science in the high school is today in a precarious condition. The seriousness of the situation is not easily overstated. This Academy of Science can certainly, it seems to me, do no better work in behalf of science than to study the high school situation. We should realize that the public high school is the chief medium for the dissemination of the fruits of scientific research and the chief source of future research workers. And above all this Academy should take a stand squarely upon the proposition that the first duty of the public high school is to train up our boys and girls into highly intelligent, public spirited citizens, with lofty social ideals and clear-cut social consciences that they may form the bulwark of democracy. Only secondarily shall our public high school be devoted to the task of producing skilled artesans.

THE NEED OF EARTH SCIENCES IN THE PUBLIC SCHOOLS

R. D. SALISBURY, UNIVERSITY OF CHICAGO

1. VOCATIONAL BEARINGS (ABSTRACT ONLY)

This paper discussed the bearing of earth sciences on the many vocations in which knowledge of the earth plays an important part. The value of the knowledge of geology to farming, mining, oil production, and all industries concerned with the production of building materials and road "metal", was pointed out. A large proportion of the active men of our country are engaged in industries which have to do with soils, ores, fuels, and structural materials. In view of this great fact, it clearly is not right that boys be placed under a heavy handicap at the outset, by having the knowledge which affects their future productivity, withheld from them. Manifestly they should have a chance to gain the knowledge which will stand them in good stead, in all their future work.

In commercial life, knowledge of geography is as important as knowledge of geology. Where commodities are, where they are or are to be needed, how they are to be transported from the one place to the other, are primary matters of geography and fundamental matters in commerce. The location of power, of fuel, of raw materials, are parts of geography, and knowledge of them is a part of the equipment of every successful factory. These are but illustrations of the general fact that knowledge of geology and geography is of vital importance to the industrial life of most men. This being the fact, public schools cannot justify their action, if they do not make adequate provision for these subjects.

2. NON-VOCATIONAL ASPECTS

There is quite another aspect to geology, which does not concern itself immediately with income or with industry. The study involves the contemplation of things which are enlarging and ennobling, in a spiritual sense. No education which leaves out training of the imagination is properly enlarging or ennobling; and where, outside of science, is there such opportu-

nity for developing and training the imagination, and where in science, a better field than geology? The time conceptions involved, the force conceptions involved, the results involved in the operations of time and force, are among the greatest with which the student has to deal. They strengthen the mind by exercise of a sort which few other subjects afford. In space conceptions, astronomy surpasses it; in their appropriate spheres, physics and chemistry are equally effective for the educational ends here emphasized; but on the whole, no science surpasses it.

No subject affords a better field for the development of that sort of attitude of mind which seems especially to fit men for life. While there are phases of the subject which deal with facts and principles which lead to inevitable conclusions as certainly as mathematical reasoning does, there are other phases in which reasoning of another sort is called for. In most of the affairs of life, decisions are based on a preponderance of evidence. In few momentous decisions is the evidence so clear that there is but one side to the question. Rarely is the evidence 100:0; it is 75:25, or 60:40, or 51:49. And training in weighing evdence which is not overwhelmingly one-sided, is one of the most important functions of education, for most of the important decisions of life are reached by the balancing of conflicting evidence. Thorough training in geology must lead to the balancing of seemingly conflicting evidence, for there are multitudes of questions to which the student of even the elements of the subject is introduced, concerning which evidence must be weighed, and a tentative decision reached, with a full recognition of its tentative character. The recognition of this character of a conclusion opens the way to a revision of judgment when additional facts warrant, and this attitude of mind is the attitude to which good education should lead, in connection with all questions where evidence is inconclusive, and this means in connection with many of the affairs of life.

No claim is set up that no other subject does the same thing. As a matter of fact, some do and some do not; but the claim is set up that the type of subject which works on strictly mathematical lines cannot, by itself, afford the best preparation for the solution of the average problems of the average man.

Neither can other types of subjects which do not involve the balancing of evidence, and the development of the power to separate what is weighty and relevant, from that which is light and irrelevant.

One of the great lessons which the world needs most to learn, is that progress comes from cumulative achievement. If every individual could be made to realize that even his tiny contribution to the sum of useful work is really moving the world along, it would add grandeur to life and dignity to all human endeavor. This is a frame of mind that should be developed in every young person, and cultivated till it becomes a habit. Where can this be done better than in connection with such a subject as geology, where the stupendous results of processes which, day by day, seem insignificant, are constantly under consideration? Nowhere else in the whole range of subjects in our ken, is the majesty of the cumulative results of seemingly slight processes more sharply emphasized, and more constantly reiterated.

Processes are at work on the land which, by themselves, would in time destroy it utterly. They have been in operation so long that they would have accomplished this result eons ago, if nature had not provided counter activities which defeat this end. Nowhere is the inter-play of constructive and destructive forces, using these terms in their bearings on man's life and welfare, more pointedly studied.

One of the chief functions of education is to put man into sympathetic and appreciative touch with his surroundings. His physical surroundings are an important part of his environment, always and everywhere, and he who does not understand, is cut off from one of the great resources of life. It is of course true that one may enjoy a landscape, even if one does not understand geology; but he will enjoy it more if he does. A man may enjoy pictures and music without understanding much about them, but he will enjoy them more if he understands. And just as some education in music and art is to be desired because it increases a man's capacity for enjoyment of the things which he sees or hears occasionally, so education with reference to the landscape, which the average man sees much more than he sees works of art, and much oftener than

he hears music, is a desideratum. To go about the earth blindly, unintelligent as to the meaning of its surface configuration, is to cut off one of the great pleasures of life, and especially one of the great pleasures of travel.

Since all men are always in touch with at least a limited part of the land surface, and most of them in touch with enough of it to find lasting enjoyment in it if they are taught to see what it means, how can we justify ourselves, if we withhold this resource from this and coming generations?

Prompted by the attitude of mind which mountains inspire, I have repeatedly watched their effect on groups of students who, for the first time, live in them long enough to have their influence felt; and I have seen, or thought I saw, how littlenesses and meannesses drop away, and how the nobler qualities come to the fore. John Muir has made much of this idea in one connection and another, and I think he is entirely right. To many men, mountains are as inspiring, as uplifting, as soul-stirring, as great essays or great poems are to others. Is it not just as great a mistake to leave the one out of consideration, as the other? To the average young *man* at least, I suspect that the mountains are quite as much of an intellectual and moral tonic, as the best that he finds on the printed page.

What has been said of the mountains might be said, with modifications, of other parts of the earth. If there are those who think the landscape of an unrelieved tract like that about Chicago unlovely, I think this feeling would be changed completely, if the grand march of events which has made that surface what it is, were understood. While it can never have the charm to the eye that some other sort of surface has, it has its own elements of attractiveness, its own beauty, to the eye which really sees. When men belittle the attractions of the level prairie, they advertise their ignorance. One may not choose to read poetry all the time. With equal education in the two, I am confident that the normal man could live contentedly with the plains longer than with poetry—even of the best.

The sea has a charm for almost every soul, but he who gets only what the eye records of color and movement, fails of the larger meaning, which, to beauty, adds grandeur. What does

the salt of the sea mean? What is the period of time of its accumulation? What volumes of rock—many times all that is now above its surface—have been destroyed in its production? What range and volume of life of which the voyager has but a glimpse, does it harbor now? What of the life of which it has been the home in the time which has passed since life was, and what of the great evolutions that have taken place within it? And what is yet to come? The great panorama of events, of processes, of changes, all of which are involved in the history of the sea, add a meaning larger than the eye, unaided, sees. To see the ocean merely as it is, is like seeing the social fabric of today, without reference to what has been in the past, or what is to be in the future.

Our period of school is all too short to give us an intelligent look into all the fields with which it would be profitable to have acquaintance, but is this field on which we live and move and have our being, one we can afford to neglect?

There is one other aspect of both geology and geography, which gives them great educational value. Neither science is completed or nearing completion. There are great things ahead in both. As an organized science, geology is older than geography, at least older than geography in its modern sense, and is the mode advanced. While geology has made phenomenal advances in the last half century, the problems ahead are so numerous and so interesting that even an elementary course in the subject, properly developed, opens up great vistas for the future. I believe it to be fundamentally important that young people should be led to see visions, and inspired by the allurements of future development. Nothing is more conducive to a right attitude toward life in general, than the feeling of the possibility of participation in the progress of the future. In this, geology is not peculiar. Only as it is less advanced than some other sciences, has it the advantage over them in this respect. In saying this, I am not losing sight of the fact that but few of those who give attention to geology in their student days, will ever go farther; but a comprehension of what is likely to come, stimulates an abiding interest, and abiding interests in various lines of work and thought, are important elements in a good education.

In modern geography the promise is perhaps even greater, since less has been accomplished. Perhaps no science touches human life and interests more closely, or in more ways. There is, I am confident, no science which, properly developed and utilized educationally, will do more for the development of good citizenship. Its substance perhaps touches the essence of material life, especially on the human side, more intimately than any other science. No other science and no other subject, unless it be sociology and possibly modern history, is likely to do so much to promote sympathetic understanding between the nations of the earth, and this is one of the greatest desiderata not only of this day and generation, but of all days and generations. For this reason, if for no other, promulgation of the knowledge of modern geography should be furthered wherever possible.

When geography and geology, and subjects which have similar advantages, occupy larger places than they now do in our educational system, I believe that our young men and women will be better equipped than they are now, to do their part in transforming a contentious world into a world of righteousness, based on mutual consideration.

WHY TEACH AGRICULTURE IN THE PUBLIC SCHOOLS?

EUGENE DAVENPORT, UNIVERSITY OF ILLINOIS

This question is honestly asked by many thoughtful people who regard education from the traditional point of view as a kind of mental training quite distinct from the exigencies of existence.

Education is all this to be sure, but it is much more than this. The mental training represents the results, the fruitage of education, not its methods, its material, or its processes.

Constructively education implies two parties, the *teacher* who represents the older generation and the *pupil* who is getting ready to live. If the older generation is to help the younger it must have suitable *material* to work upon, and as nobody

knows the future the material must be drawn from what lies at hand and from the knowledge and experience of the present and the past.

The first reason for including agriculture among the materials employed for the training of the next generation is that it is *useful*—the very reason which some would advance for its exclusion.

Historically, utilty has always been the basis of education. The non-utilitarian is a later, a very valuable, but a far less fundamental consideration than is the useful.

The primitive teacher is the father and the medicine man. Whatever the medicine man may teach of stoicism, of superstition, of religion, it is the father who teaches how to trail, to kill, how to elude an enemy, how to build a fire in the rain, how to run and dive,—in short, how to live as living is defined among savages. And the chances of the pupils living are in direct proportion to his faithfulness and ability as a learner. Considered in the large, education is not different now.

If we omit the wandering philosopher, the first schools were employed to teach definite occupation—the practice of medicine, the knowledge of law, the teaching and advancing of religion. Latterly, we have recognized a longer list of necessary occupations in which learning may be useful, and among these is farming, which for our purpose may be defined as the using of the land for the scientific support of human life upon the earth.

It is manifest that the amount of human life which can be supported upon the earth and the happiness it may attain are in large measure determined by the skill and the scientific knowledge with which we use the soil. No apology is due therefore for advancing the *argument of utility* as the *fundamental reason* for teaching agriculture in our public schools.

A second reason for including agricultural courses in our curriculum is that thereby we *connect the schools with real life.*

This connection is hard to make and many a graduate has turned out useless only because the school failed to connect its its activities with the serious business of living and the student

failed to make the connection for himself. For many years his board and bills have been paid automatically and without exertion on his own part; indeed, he has come to consider going to school as a kind of occupation,—why not after sixteen years of carefree experience? Such an unhappy result of universal education may and does occur in techincal courses, but far more rarely than in the non-technical.

Again, the materials and the applications of an agricultural course are concrete and close at hand. They lie within the student's personal purview and well within his capacity to understand.

Much of the material of education is of necessity abstract or else far away either in time or space. The concrete is clear and easy of apprehension. It is enticing, for its presents opportunities. It is exhilarating for the connection and the meanings are evident and world-wide.

Still again, agriculture provides something for the student to do. It enjoins performances. It threatens failure but it invites success. And all this is well worth while.

Much of the material and motive of education lie entirely beyond the ability of the student to exert the slightest influence upon the course of events.

He sorely needs opportunity for trying out his powers of construction as well as those of expression, and among all the subjects that offer this opportunity, agriculture is one of the best because it is concrete and because it lies close at hand. It is a man's job. It is tremendously full of opportunities and consequences. It provides good material on which the boy may whet his faculties. The prospect is eminently educational.

Incidentally, the field, the materials, and the philosophy of farming afford an almost infinite variety of engaging opportunity for meditation and for expression, and healthy intelligent expression is vitally connected with intellectual growth.

Agriculture in practice *is an art as well as a science.* As a subject of instruction it is a science. The content is eminently useful, leading to the proper conduct of the great business of production. Its study demonstrates that successful civilization

must rest upon a successful management of the lands of the earth, because food provides the only source of energy for the support of human life.

The methods of the study and the teaching of agriculture are the methods of science, and one great reason for teaching science is to develop in the pupil the faculties of exact observation, precious conception, logical analysis, and correct conclusions.

To these ends the physical sciences are especially valuable; none more so than agriculture. For precise methods no science equals mathematics, although chemistry is a good second; but when observation, analysis, induction, and deduction are all involved, no subject equals in teaching power the physical sciences, and of all physical sciences agriculture is the most concrete, the most human in its applications, and the most fundamental in its results upon the welfare of man.

In general, science must not be relegated to the fringes and fads of our education, but it must constitute the background,—indeed the very warp and woof of a system of universal education. This is because science is only another name for facts that are definitely ascertainable, and of all the body of knowledge or supposed knowledge, facts of this kind studied in their relations and in their human meanings are eminently educative.

This is not decrying those forms of knowledge or of philosophy that cannot be definitely set down. They, too, are useful, but they have no presumptive rights. True, the soul of man needs food that is not tangible, just as truly as the body needs nourishment, but even here much of the material involved is purely secondary. For example, while literature is inspirational, language is mainly a tool for its expression and understanding.

The correct teaching of agriculture, too, soon leads the student into the field of obligation, of achievement, of usefulness, of contact with God's creatures, of partnership in His Plan, and of a wholesome philosophy of life in living. No consistent student of agriculture can be either an atheist or a loafer. He cannot sleep well nights unless he does his duty day by day and works with the Lord in the feeding of His people.

When once the higher view and possibilities of agriculture are more generally understood and taught, then will universal education begin to be able to fully justify its existence and the time and the money spent upon it.

General Papers

IS THE STATE ACADEMY OF SCIENCE WORTH WHILE?

J. L. Pricer, State Normal University

In these days of flux and change, when everything is taking on new values, and when new calls are being made on all of us for time and energy and sacrifice, it may be well to scrutinize almost any existing institution as to its worthwhileness.

The Illinois Academy of Science had a most propitious beginning, enrolling as it did, almost every scientist of any prominence in the State, as a charter member. It seemed to give promise at the time of its birth, of becoming at once, one of the strongest organizations of its kind in the country. But of course, there was in this promise of vigor and usefulness, and in the plan of organization, as laid down in the constitution, a confident expectation that the State would soon recognize the value of the organization and give it the aid it needed to to function properly, in the service of the commonwealth. We seem to have been possessed of a perennial hope that the State would ultimately recognize our worth and bestow upon us the financial aid necessary to vitilize our organization, and to carry over to the point of effective service, the energy, and time and money that we as members could afford and were willing to put into it. While this hope which has been kept alive by a small bit of realization in the form of a small grant from the State Treasury for the biennium of 1911-12, and by repeated passage of an appropriation for us by both houses of the legislature,—while this hope has been a stimulating factor, during the eleven years of our history, doubtless some of us are beginning to feel that we can not continue to exist on hope alone.

Now, we are facing a large financial deficit, which we incurred under the delusion, that our hopes had been finally realized. While nearly every member from whom I have heard, seems determined to make what further sacrifices are necessary to raise money with which to meet our obligations and to put the organization intact once more and ready to continue its demands of the State, I have some intimation that a

good many are asking more seriously than ever before: "Is the Academy worth while?"

I for one would be frank to confess, that if the Academy is to continue indefinitely to be the poverty stricken organization that it has been in the past, it would not be worth the sacrifice and the effort that its members would have to make for it. Thru lack of funds for printing, we have not been able in the past to do in any effective manner, either of the two fundamental things which we state in our constitution to be the purposes for which we exist as an organization. Most of our publications have been little more than mere apologies for what they might have been. They have consisted too largely of abstracts and have been published in such small editions that the papers printed in them have been quite effectively buried from sight. They have been neither an effective stimulus to scientific research, nor an adequate means for the dissemination of scientific knowledge. We have had some splendid programs, but we might have had much better programs, could we have offered a more attractive medium of publication. Money for the adequate publication and distribution of our transactions is the one thing needed to transform the Academy from a weak, struggling and ineffective organization, to a vigorous and effective organization that would draw all the forces of science in the State together and multiply their power for good.

So, in my opinion, the question as to the worthwhileness of the Academy resolves itself into the question: "Is there any liklihood that we shall ultimately secure the aid from the State that is necessary to make it worth while?" I am persuaded that there is absolutely no question about this. We have probably been too patient and long-suffering in this matter. We have probably urged our cause with a modesty and a timidity that may be becoming to men of science, but which is not calculated to attain success in some other fields of activity. The State is thoroughly committed to the policy of aiding scientific and educational organizations by paying for the publication and distribution of their proceedings, and the states of the middle west are most of them, committed to the policy of supporting state academies in this way.

The High School Conference at the State University publishes its transactions and pays the expenses of most of the speakers on its program out of State funds. In the same House Bill No. 853 in which our illfated appropriation was included when it passed both houses of the legislature, were included the following allowances for somewhat similar organizations: to the Bee-Keepers' Association, $2,000.00; to the Dairymen's Association, $5,000.00; to the Poultry Association, $2,000.00; to the Live-Stock Breeders' Association, $3,000.00, and to the State Horticultural Society, $11,000.00. It may be that we are not exactly in the same class with these organizations. It may be that the services that we could render to the State would be a little less direct, or a little farther to seek than those rendered by these other organizations, but they are surely none the less certain, and of no less magnitude. It only remains for us to convince the Authorities at Springfield that this is the case. It is my understanding, however, that Governor Lowden vetoed our item in the bill, not because he deemed our cause unworthy, but simply because it happened to fall in the class of new requests, and under the conditions of great national stress, he had determined to draw the line at that point. So, so far as the worthiness of our cause is concerned, in the judgment of the present State government, our battle has been already won. Of course, many good things must wait on the outcome of the present international crisis, and on this account we may be compelled to wait, but I can see no cause, at the present time, for ceasing to persist in our efforts to make the Academy what it should be, with firm confidence that if normal conditions do return after the war we shall succeed.

When we consider how faithful the original members of the Academy have been in clinging to the idea thru eleven years of discouragement and disappointment; when we consider how willing they have been to contribute valuable papers to our programs, only to have them tide up for two or three years, before being published, and then finally published in so small an edition as to give them no adequate currency, there seems to be no grounds whatever to doubt the abiding faith which the membership has in the value of the organization. But we are now put to a new and more severe test. We must meet this

new financial deficit. We must pay more than we bargained for. Let us hope that this is the final test before we are admitted to the promised land. It is my hope that we shall meet this test in such a convincing fashion that the very manner of our meeting it will be a large factor in making it the final one. To this end, it seems to me to be of the highest importance that every member contribute something, even if it is only a dollar. This would show a solidarity of purpose, of devotion to the cause, and of faith in the value of the organization, that would not be shown should we raise the funds needed by a few large contributions. We should show our strength, and our devotion to the cause of science also by the amount we raise. We should not stop with paying the debts already contracted. We should provide also, and speedily, the funds needed with which to publish the papers of this meeting.

The special address by Dr. Coulter, and the symposium on Science and Education, were planned specifically for the accomplishment of a definite and very much needed piece of work, and it is obvious that very little will be accomplished in the direction intended unless these addresses are given wide circulation. If, with the aid of a few large donations from wealthy men, we can raise enough money, not only to pay for the two volumes already published, but to publish the papers of the present meeting, we will have in this accomplishment itself, an unanswerable argument to the effect that we as a body stand ready to do our part of the work for the State that can be done only by such an organization of the science forces within it.

This is a day of organizations. Hardly any cause can prosper as it should, in these days, unless it is backed by an organization. I would not underestimate the value of the individual worker in science. Science itself, is the sum total of what individuals have done, and yet, it is obvious that no one has given his full measure of support to science when he has served it merely as an individual. He must join forces with others for the accomplishment of ends that cannot be accomplished by individuals, working alone. The papers and discussions of this meeting will develop the fact, I am sure, that science is not functioning in society as it should. In fact, I am sure that it will be shown that if certain present tendencies in

education are allowed to continue, science will function among the masses of people, in the future, to a less extent than at present. Now, who is to check these tendencies, if not the men and women engaged in science work? And how can we deal with such problems except thru some organization? We who, are devoting our lives to science, should know better than any other class in society, the great need of the further prosecution of scientific research, and of the wider dissemination of scientific knowledge among the people, and so because of this knowledge, we are charged with the responsibility of doing whatever lies within our power to further the interests of these things. If we do not do every thing that we can to create public support and demand for scientific research, such support is likely to be lacking. If we do not assume some guarding care over science education, it is likely to be neglected. Science, like everything else, is always in competition with other interests, and most of these competing interests are backed by active organizations. Hence, it follows that if science is to hold its place and perform its true mission in society, those who understand and appreciate it best must be organized and in a position to assert its rights and to advocate its cause at every turn, and in the most effective manner.

In conclusion, I would say, then, that this is no time for any member of the Academy to give even a single thought to withdrawing his support from the organization or to shirk his share of the responsibility in helping it out of its present difficulties. In this day of patriotic appeals, when young men on every side of us are making sacrifices which are out of all proportions to anything that most of us shall be asked to make, the present difficulties of the Academy should shrink to exceedingly small dimensions, and we should do with a generous hand, what is to my mind, plainly our patriotic duty, both to society at large, and to the State of Illinois. It would be a sad commentary on the men of science in Illinois if this Academy should be allowed to perish or even to languish in this time when it is needed as never before.

THE STATUS OF BIOLOGY IN ILLINOIS HIGH SCHOOLS

FRED HARTIN, RANKIN, ILL.

The present status of biology in Illinois high schools is shown by the accompanying tables, which need only a brief explanation. The data for these tables were gotten from the report of the High School Visitor of the University of Illinois and from 275 replies to a questionaire sent to each of the public high schools accredited by the University of Illinois.

Table I shows the sequence of subjects in 169 Illinois high schools. Fourteen different arrangements are being used. The most common order of subjects is physiology, zoology, botany, this order being followed in more than half of the 169 schools. Two reasons are commonly given for using this order; first, that physiology is a science with which high school pupils are already acquainted and for this reason can be more profitably taken up first; secondly, because physiology is required by law to be taught in the ninth year.

The second most popular sequence of subjects is botany, zoology, physiology. This order has been adopted by the Biology Section of the Illinois High School Conference as the most logical and most pedagogical.

Table II shows eighteen different arrangements as to amount of biological work offered. The features of interest shown in this table are the fact that the half year arrangements is quite prevalent, that seven schools offer none of the three biological subjects, that twenty-nine offer no botany, forty-nine no physiology, and forty-seven no zoology.

Table III shows the amount required in 250 schools. Schools requiring all three subjects are mainly small high schools in which no electives are offered. The ninety-eight schools that do not require any of the biological courses are mainly the larger high schools which offer two or more courses. The requirement of some biology in certain courses in these schools is quite

general but the selection of the course by the student is essentially the same as having none of the courses required.

Table IV shows what percent. the enrollment in each course is of the total enrollment of the year or grade in which the course is offered. Generally speaking, each biological subject is taken by about one-half of the pupils in Illinois high schools.

Tables I, II, and III show a general lack of uniformity in the organization of biological courses in Illinois high schools. This lack of uniformity seems to indicate a diversity of opinions regarding the aim or value of biology on the part of biology teachers, high school principals, and superintendents. If this be the true state of affairs, the low percentage of enrollment in biological courses is not so surprising.

TABLE I.

SEQUENCE OF COURSES

Sequence	*Number of Schools*
Physiology, zoology, botany	86
Botany, zoology, physiology	39
Physiology, botany, zoology	19
Zoology, botany, physiology	5
Botany, physiology, zoology	4
Zoology, physiology, botany	3
Zoology, physiology and botany parallel	2
Zoology and physiology parallel, botany	1
Zoology and botany parallel, physiology	1
Botany, zoology and physiology parallel	1
Physiology, botany and zoology parallel	1
Physiology and botany parallel, zoology	1
All three parallel	1
Physiology, others optional	5
Total	169

TABLE II.

AMOUNT OFFERED

Courses offered— *Botany. Zoology. Physiology.*	*Number of Schools*
½ year, ½ year, ½ year	247
1 year, 1 year, 1 year	2
1 year, 1 year, ½ year	30
1 year, ½ year, ½ year	6
½ year, ½ year, 1 year	2
½ year, ½ year, 0 year	23
½ year, 0 year, ½ year	9
1 year, 1 year, 0 year	10
1 year, 0 year, ½ year	4
½ year, 0 year, 1 year	1
1 year, ½ year, 0 year	2
0 year, ½ year, ½ year	3
1 year, 0 year, 0 year	3
½ year, 0 year, 0 year	4
0 year, 0 year, ½ year	19
0 year, 0 year, 0 year	7
1 year of botany, 1 year of zoology and physiology	1
24 weeks of botany, 24 weeks of zoology, 12 weeks of physiology	1
Total	384
Offering no botany	29
Offering no zoology	47
Offering no physiology	49

The rise and fall of high school subjects during the past fifteen years.

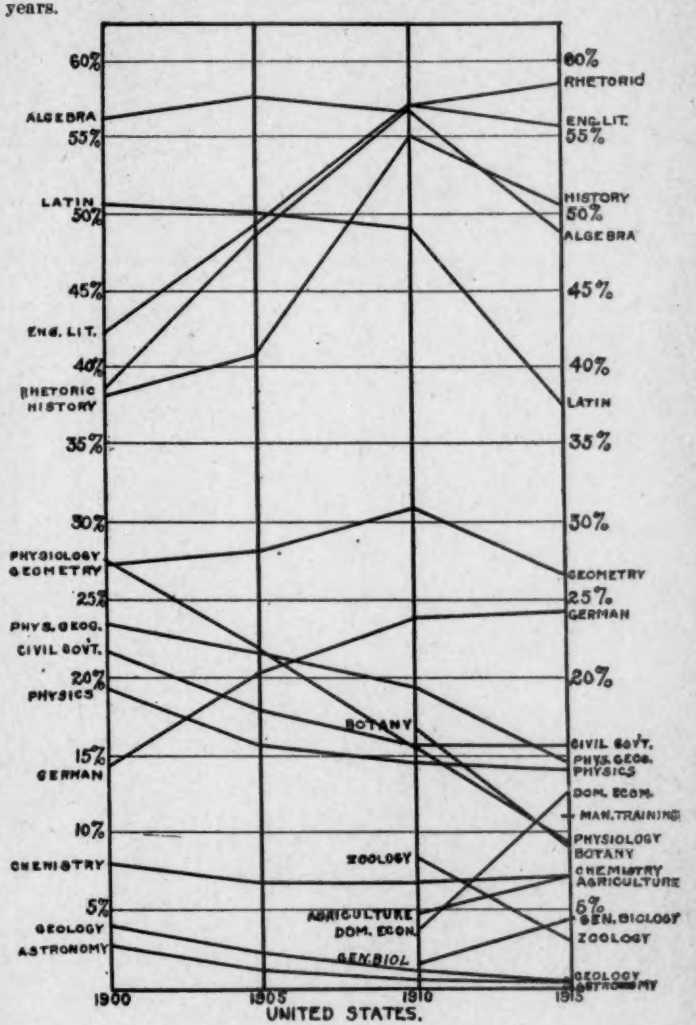


TABLE III.

AMOUNT REQUIRED

Courses required.	*Number of Schools*
All three	49
Physiology only	79
Botany only	3
Botany and zoology	13
Botany and physiology	5
Zoology and physiology	3
None	98
Total	250

TABLE IV.

PERCENT. OF STUDENTS ENROLLED IN BIOLOGICAL COURSES

	Botany.	*Zoology.*	*Physiology.*
Enrollment in courses	5407	4051	8487
Enrollment of grade	9951	9367	13247
Percent enrolled in courses	54.3	43.2	64.0

THE REORGANIZATION OF HIGH SCHOOL SCIENCE

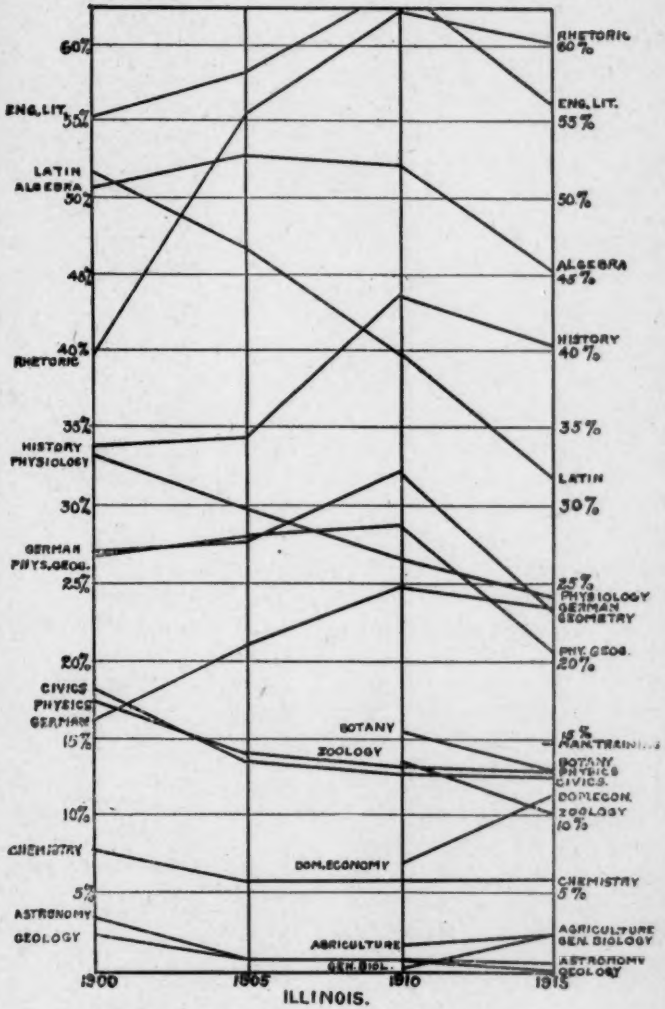
FRED D. BARBER, STATE NORMAL UNIVERSITY

THESES

1. The day has passed when it was pertinent to ask whether high-school science needs reorganization: high-school science is now being reorganized.

2. The *laissez faire* attitude of teachers of the biological sciences and of earth science, has been a large factor in bringing about the marked decline in those sciences in the high school and the substitution of agriculture, domestic economy and general science in their places.

3. The shift from "pure science" to applied science has occurred chiefly in the first two years of the high-school science curriculum. This shift has been the result of a wide-spread conviction that the science generally offered in the first two years was scarcely worth while.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ENG. LIT. 55%
LATIN
ALGEBRA 50%
45%
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RHETORIC
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HISTORY
PHYSIOLOGY
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GERMAN
PHYS. GEOG.
25%
20%
CIVICS
PHYSICS
GERMAN
15%
10%
CHEMISTRY
5%
ASTRONOMY
GEOLOGY
1900
1905
1910
1915
RHETORIC 60%
ENG. LIT. 55%
50%
ALGEBRA 45%
HISTORY 40%
35%
LATIN 30%
25%
PHYSIOLOGY
GERMAN
GEOMETRY
PHY. GEOG. 20%
BOTANY
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DOM. ECON.
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GEN. BIOL.
BOTANY
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CIVICS.
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ZOOLOGY 10%
CHEMISTRY 5%
AGRICULTURE
GEN. BIOLOGY
ASTRONOMY
GEOLOGY

ILLINOIS.

4. Standpatters in science are now face to face with a condition, not a theory; it behooves the adherent of "pure science" to wake up if they would have the best elements of the old regime preserved.

5. Reorganized science for the first two years of the high school should preserve the elements of historical significance and scholarship from the old and incorporate them with the elements of real worth and interest from the new.

6. The "ordinary" four-year high school is impossible of definition; it may have two teachers or it may have twenty teachers; it may be strictly rural, or it may be strictly urban in character.

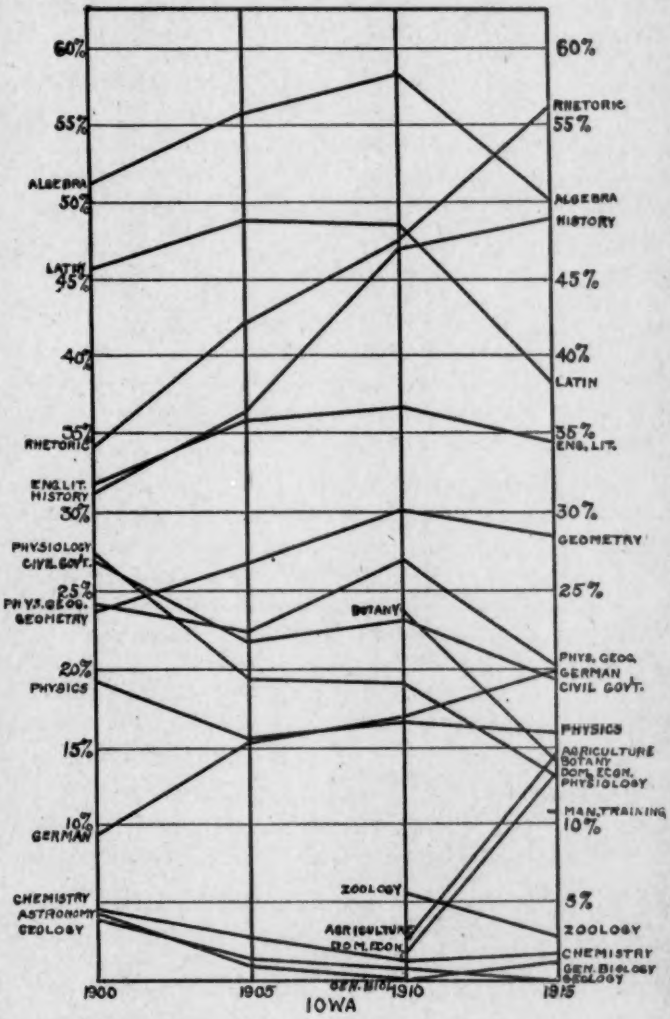
7. It is highly desirable that a nucleus of the science course shall be found which is equally applicable to high schools of every character; such a course must meet the needs of all classes of high school students.

8. Such a stem course is possible; it may as well be known as a two-year required course in general science. Such a course should be organized from the materials found in the pupil's environment; the first year's work should be found in a study of the home, the school and street leading from the home to the school and should be largely physical science material. The second year's work should consist of a study of an outer circle of environment, plant and animal life in the garden, the orchard and the field, together with personal hygiene and community sanitation.

9. In this stem course human welfare will be everywhere emphasized. Its purposes and methods will differ much from those of either the old special sciences or the new applied sciences.

10. This stem course must not be the only science offered in the high school; it must be followed by elective courses in agriculture and domestic economy and courses in the special sciences to the extent that the facilities of the school admits.

11. If the 6-3-3 plan is adopted the stem two-year course in general science may well be put in the eighth and ninth grades.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PHYS. GEOG.
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CHEMISTRY
ASTRONOMY
GEOLOGY
BOTANY
ZOOLOGY
AGRICULTURE
DOM. ECON.
GEN. BIOL.
PHYS. GEOG.
GERMAN
CIVIL GOVT.
MAN. TRAINING
1900
1905
1910
1915
IOWA

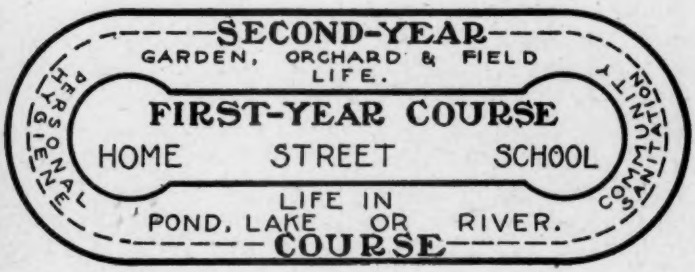
12. Teachers of science in the high school should wake up to the situation and exert every possible influence to bring high-school science out of its present chaotic condition. They should agree upon some sort of stem course which can be generally adopted.

TABLE I.

Table I. Showing percent. increase (italic face) or decrease, during the 5 years from 1910 to 1915 in the percentages of students enrolled in the various high-school subjects:

Subject	*United States*	*Iowa*	*Wisconsin*	*Illinois*	*Ohio*
Physics	3%	4%	4%	3%	8%
Chemistry	7%	*15%*	*17%*	4%	10%
Physical Geography	25%	35%	33%	24%	18%
Physiology	38%	31%	30%	8%	44%
Botany	45%	39%	30%	17%	28%
Zoology	59%	54%	50%	22%	49%
Agriculture	*54%*	*513%*	*24%*	*52%*	*231%*
Domestic Economy.	*241%*	*593%*	*237%*	*65%*	*340%*

The rise and fall of high school subjects during the past five years.



THE RELATION OF GENERAL BIOLOGY TO MEDICINE AND DENTISTRY FOR THE PEOPLE

V. A. Latham, Chicago

"It is characteristic of Science and Progress, that they continually open new fields to our vision." (Pasteur.)

Preventive Medicine, when viewed in its broad, general sense, indicates not only the prevention of disease and its consequences to the individual, but of still greater import to the mass of people. So does the Teaching Forces and Medical inspection of schools primarily concern themselves with the individual, thereby deserving a permanent place in the efforts being made to understand and eliminate disease and conserve health; and also in a far reaching way, it embraces the betterment of the masses both in its hygienic and economic aspects.

Organized beings are continually acted upon by their environment, and life is an expression of their continuous reaction. When reaction ceases, the organism becomes the passive prey to surrounding forces, life is extinct and has been succeeded by death. Living, the organism withstood the force of gravity and raised itself from the earth; maintained an equable temperature despite the surrounding alterations from heat and cold; retained the moisture of its tissues against the drying influence of the encircling air. In reacting against its environment, a living organism acquires its development, so that the endless struggle so bound up with life is not without advantages. So long as the organism is able to maintain the equilibrium of its functions, the condition is described as *health*. All creatures, however, are only capable of reacting against a special and very limited environment, hence a relatively narrow one. An Aviator succumbs to the rarefied air and cold before an altitude of 9,000 meters is reached, unless properly protected. Whilst the immense weight of water crushes in upon the Diver who dares brave the watery depths.

Civilization and disease go hand in hand, and the physician of today is to teach preventive medicine more than to treat

disease. The glutton, the inebriate, the profligate will persist despite the Reformer; the clash from mailed fists will go in defiance of the Humanitarian; and in the world of trade, where misdirected commercial zeal racks the nerves and ofttimes blasts the mind, the physician's warning will go unheeded. Indeed, so lightly do we regard our health that while our Departments of War, Navy, State and Agriculture are considered essential, the safeguarding of the people's Health finds no place in the Cabinet—the Cabinet that conducts the affairs of our Nation. Fortunately, there is some improvement along this line, and Teaching and Diplomas are now being given in Public Health.

Our Marine Hospital Corps has done some excellent work in Malaria, Pellagra, Hookworm and water-borne diseases, and we feel an incentive to carry on this work. Several reasons exist for the apathy shown. First and foremost, a careful guarding of the Medical Practice Acts which at the present time are most unjust to the practitioner by limiting practice according to Statehood. This country is called United, but the laws are far from being unified according to the legislature of the State. It reminds one of the old question, "When is a man a man? When he is asleep!" The existence of faddists may be a help but are oftentimes a danger unless they are endowed with a broadly educated brain and a high sense of justice and equality. And to no one is this truer than to you as Biologists, who realize into what problems you may be drawn.

How soon set theories are overthrown by a simple wild plant or animal appearing in an area it seldom or never occurred in before! The Mounds so often regarded as Man's work have been proved as natural remnants of waterborne glacial materials.*

The question of pay to scientific workers in all countries has been a source of regret and only in Europe we have to look for government aid and appreciation of some student's discovery. Better give some encouragement now and not when a man has died! Problems of scientific education, the greatest discoveries and inventions have been made in the past by men with little

*Crook, Composition and Origin of Monks Mound. Trans. I. S. Academy of Sci., 1916.

formal scientific training, and in fields quite outside their ordinary vocations. Thus James Watt was a maker of mathematical instruments, Von Leeuwenhoek a Dutch spectacle maker; G. Stephenson, a colliery fireman; Arkwright, a barber; Edison, a railway porter; Cavendish, Boyle, Sir William Herschel and other great workers in the field of pure science might be described as gifted amateurs. No rigid distinction could be drawn between pure and applied science. Wireless telegraphy afforded a good instance of purely theoretical work leading to unforeseen but vast practical results. The telescope has revolutionized our conception of the universe; the microscope our conception of life. The significance and difficulties of correct microscopical observation must be believed to be very generally underestimated and that accurate observation is by far the most difficult art which mankind ever essayed.

The endowment of Institutes is a help but one, which if not carefully directed, becomes difficult to enter thru cliques, narrow portals or set opinions. Science knows no master, neither does she remain at rest. For cardinal principles of Living, we must know Biology (the science of life), together with the component sciences as given here, Palaeontology, Zoology, Morphology, Geology, etc., for otherwise the physician and dentist cannot grapple with the results of the deviations or deformities that come to his practice.

The scientific or professional branches require B. S. degrees rather than those of arts, for time and money spent is all too short for the foundations we *really need* in these rapid times. Formerly the classics held their sway, and it goes without saying, nothing should be excluded, for who does not need the languages for reading work, the chemistry rather than mathematics for basic reason, but the finality must be the test; and we find in this century, the Physician and Biologist are far more allied to each other and the Chemist and Physiologist with the Anatomist than the cultured classic or mathematician, or even the historian.

How is the relationship of Biology to Medicine and Dentistry borne out for the people? In so many ways, it is difficult to exclude them. First, a simple example may show a comparison

between the truth and a theory or a fad, Medicine in its broad sense and Eddyism.

Take one of the lowest and simplest forms of life found everywhere in some type or other in the water, in the slime, in the soil. The Amoeba—Geology claims it and even adds to it; the Zoologist follows with many forms and places; the Biologist regards it as a simple type; the Botanist sees food for thought in its flow of protoplasm and its relationship to that monstrosity but wonderful ne'er do well, what is it and where is it "The Myxies"; the Chemist analyzes its chemical composition and the physiologist regards it as a complex animal and wonders at its food supply and vacuole. The Histologist stains its Protoplasm, Spongioplasm and other structures and endeavors to spot the nucleus. The Pathologist with his confreres, the Physiologist and Histologist squabble over its amoeboid movement and phagocytosis. The one that it is a Leucocyte or white blood cell, the other that it has a vicious habit and gets into the wrong environment, the intestines, liver or mouth.

That it is a food source, the Bacteriologist not to be outdone, endeavors to horticultural it by adding soup, salts and drugs and claims it as a fine inducement to growth for plant culture in soils; and again has a puzzle to grow some other sorts; whilst the Physician or Internist is busy hunting in the excreta with the laboratory worker to end those intense pains, and the Dentist, not to be outdone, says to his colleague "That's the cause of loosening and falling out of teeth, Pyorrhoea." "No, it's not," said his friend, "it's an 'Eater of Bone,'" and so helps the oral surgeon to get a case, when up comes the preventive man and says, "You're wrong. It's doing its duty; it's mostly a good scavenger and saves the youngsters some work."

Gentlemen, my story includes the *Amoeba Proteus, lobosa, radiosa villosa, verrucosa and Endamoeba Histolytica, Tetragonus, Buccalis and Endamoeba Coli of Panama and India, whether in the intestine, liver or mouth.

Amoeba of the mouth not a recent discovery as some writers describe, but the Entamoebae Buccalis Kartulis or Amoebae

*Endamoeba is parisitic for man, and the Amoeba a free living saprophyte.

Gingivallis of Gros 1849, and the Amoeboid action of the Leucocyte; each and all are known to you, each and all have taken years of study and lots of paper and printer's ink, each and all are nearly strangers even to you, eminent in your specialties, and we all need to follow Kipling when he said:

"It ain't the guns nor armament nor funds that they can pay
But the close co-operation that makes them win the day.
It ain't the individuals nor the army as a whole,
But the everlasting team work of every bloomin' soul."

The Physician and the Dentist should have a better knowledge of Biology and must of necessity be a trained Microscopist. How much we need a better teaching in this subject, in all its departments, the use of illumination and the apparatus for the purpose, the smattering in most of our schools and colleges is deplorable. We need a course such as Professor Gage's at Cornell. Year by year the interest which is taken in the world around us, in the unspoiled works of Nature, continues to increase. It is now recognized that to train the powers of observation is one of the most important necessities in general education, and that it is far better for everyone to train himself naturally through the interest aroused by the subjects considered, than to learn nothing but second-hand facts from others. Whatever line of study is taken up, if any real progress is to be made, some aid to vision must be sought to see the structure and minute facts of the life of the subject. Here it is that the microscope comes into play, and it is not too much to claim that besides being the source of additional interest the instrument is a great educator, that is to say, it trains without appreciable effort the hand to be skillful, the eyes to appreciate, and the brain to elucidate. There will be times when the most enthusiastic Nature-student cannot be out of doors long dark winter evenings, wet days, even in summer, when indoor work must take the place of outdoor. It is then that work with the microscope will prove such a fascinating hobby and lead us into regions where it is impossible to travel without it. The whole science of bacteriology and the discoveries of the minute fungi which cause disease and putrefaction, which give the taste to butter and the flavor to cheese, entirely depend upon skilled

work and high powers of the microscope. It may be worth while to recall the address by Sir James Paget of England in 1880 on plant diseases and their relation to man; the oak-galls having been the favorite. The Crown-gall in both wild and cultivated plants is analagous to sarcoma in man. Dr. E. F. Smith has recently produced a complex tumor or embryoma. It may not be out of place to remind the members here that Prof. T. J. Burrill was, I believe, the *first instructor* in Bacteriology in the United States, for he gave Bacteria in his Fungi courses in the 70's and his paper on the Pear Blight in 1879.

The treatment of mouth and the gastro-intestinal tract is where we all work together, the internist, the chemist, the bacteriologist, zoologist, pathologist, and dietitian. Use here of Micro-analysis shortens time, is accurate, takes less material, fewer re-agents, and the results are the same. The sooner the Universities give a full medical standing in the 1st, 2nd, 3rd years for Dental students, or require the M. D. degree entire, the better it will be for all concerned; then specialize in the subjects desired as Occulist, Aurist, Dentist, etc.

To be able in this day and age to treat a case intelligently, medical and dental men must know germs, culturing, vaccines, serum-therapy, surgery, and even law in its medical and forensic aspects.

To the better understanding we need Biology in its broadest sense, the thorough mastery of the Microscope, its accessories, and we need to know and use the Polariscope and the selenites. Cheese yields various moulds and parasites. Aspergillus glaucus and Penicillium glaucum, cheese mites. Milw, water and all other foods and beverages require a good knowledge of biological studies even to the Textiles, for fibres yield errors and much amusement, as well as work to identify and tarce in disease and for Medico-legal examination.

Flesh foods are important to all mankind in one way or another as Food and even Dangers in their uses.

The Zoologist is required as well as the Botanist, Biologist, the Veterinarian, the Chemist, the Doctor and the Dentist. Hence closer co-operation with one another is much to be de-

sired, for research, for disease and cure, and last but greatest of all for the welfare of the Country, the People and the Academy.

The Normal schools are amongst some of the largest factors in the educational scheme of this country and they must remember to include teachers who are trained in health work and a broad knowledge of dental study and the far reaching dangers of dirty mouths, which are so potent a factor in children. The time for dental examinations and treatment are unfortunately made too late; they need to begin at home and the kindergarten, when the teeth should be filled, the gums treated as well as the nose and throat; but today, I regard as one of the most vital helps for the race of mankind, the very early expansion of the jaws to make room for the development of the bones of the face and head, for about 60 percent. need it badly. It is easy to propound questions. It is often very hard to answer them. But when the answer involves the discovery of a principle, especially of a principle that can be utilized for the preservation of health, that answer is worth striving for.

Tropical Medicine has surely taught us to value all the group of sciences mentioned for the value of discovery has reclaimed barren tropical areas, drained Mangrove swamps, cultivated soils and marshes, saved thousands of lives from death by cholera, malaria, plague, leprosy, dengue, prevented smallpox, and for physicians no higher praise and tribute can be given than that paid Edward Jenner by Thomas Jefferson:

"You have erased from the calendar of afflictions, one of its greatest. Future nations will know by history alone that the loathsome smallpox has existed and by you has been extirpated." The discovery of wonderful seeds, plants and animals, and as for Economy and Colonization, the worth can never be estimated.

See. Importance of Biology as applied to Dentistry. Ch. F. L. Nord. Dental Cosmos. 1916.

Compare, if you will, the weakness of the new religionist who without a proof can question so formidable an array of thinkers, from the days of the Palaeontologist to the Physiologist of today even to that startling phrase, the immortality of the Protozoa (Weismann).

Are we and have we not proved that Nature buries her secrets deeply, not lightly or weakly for human eye to see? To those who dig and delve, her whims, her schemes may some day be unbared. To offer you to observe, reflect, compare, record, not one alone, but together prove that Nature is God's own Servant for the Truth.

Ten years after the Battle of Sedan, and thirty-three before the present war, the great French physician, Charcot, in his "Lectures on Senile Diseases", p. 20, (Trans. New Sydenham Soc. Lond. 1881. Trans. by Tuke) indulges in comment on French, German and English medicine that is perhaps more striking *now* than when first it was written. The pride of the Frenchman in Laennec and the Stethoscope is evident. Slow waking up of the German to modern scientific medicines and the influence of Schonlein, of Purpura fame, and of Rokitansky is charmingly described. For nobody should forget that Science owns no country and is the property of no race. His contrast of "the exclusive and illiberal ideas of the Prussian savant," (Virchow), with "the grand words of one of England's greatest physicians (Graves) is striking:

"The empire of reason, extending from the old to the new world, from Europe to the Antipodes, has encircled the earth; the sun never sets on her dominions—individuals must rest, but the collective intelligence of the species never sleeps."

A DEFINITION OF A STATE MUSEUM

A. R. Crook, State Museum

Meager, ill kept, uninteresting collections of various sorts housed in some museums have so often made such a lasting impression upon visitors that those persons ever after have had an improper idea of what a museum in the proper sense should be.

Such has been the experience of the Illinois State Museum which for many years was so poorly cared for that the impression which it made upon legislators was an unfavorable one. The definition which these men would give for a museum is totally different from the one which I would emphasize. And since they never visit this museum now and are unacquainted with any other, there is no hope of their ever bringing out a revised edition of their definition.

I would define a museum as an "institution designed for the collection, preservation, investigation and display of objects which illustrate in concrete and tangible form the knowledge and skill that men have in science, in art, in manufacture and in business," and a State Museum is an institution which illustrates in concrete and tangible form the things that men of science, of art and of business in the State know and can do. Thus it is a repository of ideas and of deeds rather than simply of objects. It illustrates at every turn the knowledge that men have. Instead of being a collection of things it is a collection of thoughts.

The various departments in such a museum would be designed to graphically illustrate what men have discovered in those departments. The division of botany would be more than simply a herbarium—a collection of dead plants. Instead it would be so fitted as to point out what our botanists know about all kinds of vegetation in the State—what they have learned concerning appearance, life habits, relationships, noxious qualities, medicinal values and possible commercial utilities of the three or four thousand plants which grow in Illinois. Artists in glass and wax would build groups to depict the

leading regions of the State from sand dunes, lake shores, river bottoms, valleys, and prairies, to forest regions, and give tangible illustration of the excellent work being done by the Academy "Committee on Ecological Survey."

The tree exhibit would contain not only the trunks, leaves and fruit of the hundred and fifty kinds of trees growing in the State, but also fine illustrations of magnificent trees and samples of their products—boards, laths, shingles, clothes pins, wood pulp, paper and all the things made out of wood pulp even to car wheels. There would be a long list of things which illustrate what dendrologists know and what artists and manufacturers can do.

The zoological section would consist not simply of a great multitude of shells, insects, fish, birds and mammals, but would be a fascinating place where the visitor could delight in the varied and strange forms of insects and fish; the beautiful plumage of birds; the fine fur of mammals; the life-like groups, where artist and man of science combine to depict nature in her most charming and instructive forms and through cunningly devised arrangement of animal, flower, leaf and rock to explain what men know about the life habits, history, relationship and utility of the multitude of creatures which constitute the zoological world.

In the department of ethnology as well as that of zoology there is a great field for artistic group work. At the Illinois State Museum there is promise of remarkable work being done in the field of ethnology, thanks to a gift of three thousand dollars one week ago today by a generous friend of the museum and thanks also to the promise of another friend to give the museum in the near future one of the greatest archaeological collections of its kind in the country.

The amount of time represented by man on the earth is but a fraction of the years involved in the earth's history. If we go back of modern history, back of the art of writing, back of the stone age, back of the "psychozoic era"; back to reptiles, to fish, to the dim and nebulous times of gradual accretion of dust of the universe to form a world, each step is an interesting field not because of objects but because of what we know of them.

No department of the museum can exceed this in importance or fascination nor afford a better opportunity to show what men know and what they are discovering. These form the divisions of general geology, paleontology, mineralogy and petrography.

Similarly a successful museum represents what physicists and engineers know and can do. In such a museum instead of a constant repetition of signs reading "Hands off," "Do not touch the objects," etc., one reads such signs as this: "Turn on the light and see a magnificant spectrum," "Touch button to obtain view of axial figures," "When lighted these specimens show marked fluorescence," "Turn the button and start the machinery," etc.

No department of a museum could be more attractive than that which concerns itself with the knowledge and accomplishments of our physicists.

Very interesting, too, would be the departments of chemistry, of astronomy, of the manufacturing arts and of the fine arts. All of these and of those mentioned before have the common purpose of speaking in a voice perpetually audible and readily understandable concerning the ever increasing fund of knowledge of our investigators and artists in all departments of human endeavor.

A survey of these few points impresses us with the wealth of material upon which a museum can draw. If it is a poor uninteresting place it certainly would not be because of lack of subject matter but because of lack of energy, of imagination or of money on the part of the officers or workers in whose keeping the institution is placed.

A museum is then a voice announcing the valuable work of our men of science. It speaks with no discordant note, with no attempt to silence or minimize other voices, but to swell their volume and to add to them becoming an extra voice as of one crying in the wilderness, "Behold the attainments of science and the coming of the hosts of knowledge."

Papers on Botany

PRECOCITY IN A FURCRAEA

WILLIAM TRELEASE, UNIVERSITY OF ILLINOIS

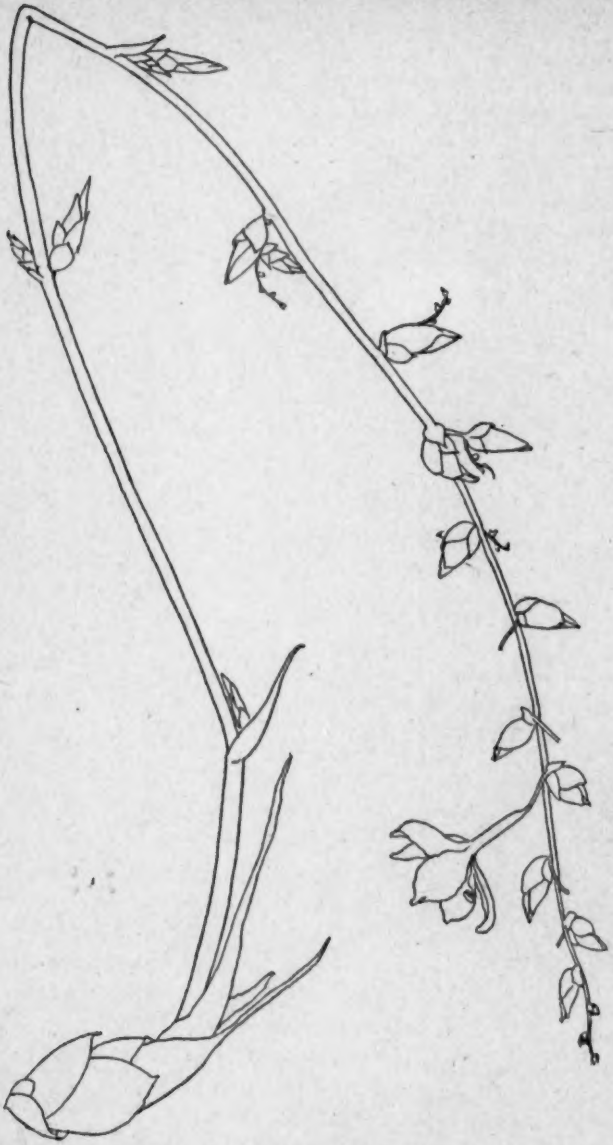
A number of cases are known in which seeds germinate in the fruit, either normally as in the mangrove, or exceptionally as in watermelon and citrus fruits. With these phenomena are connected, though not very logically, the many cases of bulbil production in flower-clusters,—often of unlike morphological character, such as *Poa, Polygonum, Allium,* etc., offer. In a way comparable with these, are the cases of flowering precocity on suckers, offsets, etc., of such monocarpic plants as *Agave* and *Furcraea,* where these diminutive derivatives of a mature plant flower when it does.*

Unlike *Agave,* the related genus *Furcraea* does not fruit as a general thing, but is propagated by bulbils that accompany or follow the flowers, as in the cases already referred to. Commonly, these bulbils fall from the parent stock when they have reached what may be considered normal development, and it is by their use that many of the Furcraeas, like the related Sisal Agaves, are propagated commercially.

To my observant correspondent Mr. L. J. K. Brace, of Nassau, I owe knowledge of a very striking and exceptional illustration of sexual maturity of *Furcraea* bulbils concurrently with the mother plant, which may be compared in its physiological meaning with the concurrent flowering of offsets in this and other genera. The case is that of a small plant of *Furcraea tuberosa* obtained from Mr. Joseph Chamberlain's estate on the island of Andros, and supposedly derived originally from Kew.

When already in pole and about to flower, the scape of this plant was broken over by a wind storm, and in this position, still connected with the rest of the plant, it went through the usual process of producing unfruitful flowers and abundant bulbils. The unusual part of its history is that many of these bulbils, remaining attached to the mother plant, and without

*Trelease, Ann. Jard. Bot. Buitenzorg. II. Suppl. 3: 909. (Furcraea).



FURCRAEA TUBEROSA

more than the customary leaf production of such bulbils, developed into slender scapes—in one case, at least, two feet long, as freely floriferous and bulbil-bearing as the usual ultimate branches of a normal inflorensence.

SOME PERCHED DUNES OF NORTHERN LAKE MICHIGAN AND THEIR VEGETATION

GEO. D. FULLER, UNIVERSITY OF CHICAGO

The sand dunes of the Lake Michigan shore may, for the purposes of our discussion be divided into groups according to their location. Those at the south end of the lake, situated principally in Indiana, differ in some respects from the sand areas scattered along the east shore upon the lower peninsula of Michigan. The formation of the Indiana dunes is in general more recent and is to be referred to that period during which the waters of the lake have stood at approximately their present level. A smaller portion of the area was developed during the later stages of the glacial Lake Chicago.

In contrast with this the dunes of the lower peninsula of Michigan are to be associated with a more remote origin connected with bodies of water or ice belonging to former ages.

It is the purpose of this paper to record a few of the phenomena connected with the occurrence of various dunes found upon the islands in the northern part of Lake Michigan and upon the adjacent mainland.

Nearly all the dunes of this and similar regions are of *lacustrine* origin, being formed from sand thrown upon the shore by the waves and then caught up by the wind, carried inland, and piled in characteristic mounds and ridges. Some of these lacustrine dunes have accumulated upon the existing beach and may therefore be called *beach dunes,* while others are developed upon substrata elevated some distance above the beach and may be termed *perched dunes.* They may have been formed either by a wind eddy at the top of a short cliff, or have travelled inland from the beach over higher land. The term is

also applied to dunes formed upon an old beach which from the subsidence of the lake level finds itself much above the level of existing waters.

The beach dunes are characteristic of depositing shores and to this class are to be referred those of the southern end of Lake Michigan, while perched dunes are more characteristic of eroding shores and are frequent along the east shore of Lake Michigan, ranging from 10 to 400 feet above the present level of its waters.

While it is evident that the greater part of the shore dunes of Michigan belong to one or other of the types just mentioned, it is conceived that dunes may also have been formed from sandy material deposited by the action of ice and water about the margin of the Pleistocene ice sheet and afterwards worked over by the wind. Dunes of such an origin may be termed *terrestrial* in contrast to those of lacustrine formation that derive their material directly from the lake. It seems probable that some of the interior dune areas of Michigan are of this type and recently evidence has been obtained that at least a few of the shore dunes are terrestrial rather than lacustrine in their origin.

THE NIPISSING BEACH DUNES

The beach developed by the water of the Nipissing Great Lakes has been carefully traced by Leverett and Taylor.[1] Upon portions of this beach sand dunes have been subsequently deposited, although on account of the comparatively recent date of its development, they are nowhere very extensive. At a point near the north end of the bar separating Portage Lake from Lake Michigan, a gravel ridge between 15 and 20 feet above the present lake is partially uncovered just back of a low fore-dune and again just north of Point Betsie lighthouse is a similar ridge. From their height and general character it seems probable that these beaches are Nipissing. On either side of the mouth of the Platte River the Nipissing beach does occur, extending for several miles, covered in many places by low grassy dunes, but none of these appear as interesting as some development upon the Fox and Beaver Islands.

[1] Leverett, Frank, and Taylor, F. B., The Pleistocene of Indiana and Michigan and the history of the great lakes. U. S. Geol. Surv. Monograph 53: 447-463. 1915.

On South Fox Island the lighthouse stands upon an isolated mound of sand at the extreme south of the island. This mound is a dune some 70 feet high and 200 yards across, standing upon a gravel bar some 400 yards long and half as broad, and connecting it with the main portion of the island. From the ridges of the island to the lighthouse dune the ridge is swept bare for more than 200 yards and its surface is seen to be about 20 feet above the lake and this agrees so well with the elevation of the Nipissing beach that it seems probable that it was actually formed by those lakes.

Upon the Beaver Islands the beaches have been traced by Taylor and there is no doubt as to the identity of those occupied by the dunes under consideration. Upon the west shore

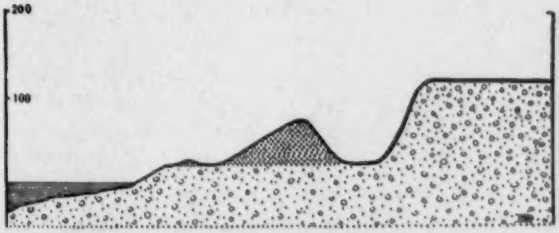


Fig. 1. Diagramatic east-west cross section of a dune perched upon a wave-cut terrace of Nipissing age. Beaver Island, Mich. Vertical height in feet at the left of diagram. Horizontal scale one-half the vertical.

of High Island the dunes form a crescent about the inner side of a bay about two miles across. The shore is gravelly throughout and just back of the fore-dune a well developed beach is seen, partly covered with partially fixed low dunes. An exactly similar area about 100 yards broad is to be seen on the west shore of Beaver Island. At the northern end of the west shore dune area of Beaver Island this low complex of beach gravel and small superimposed dunes merges into a sand cliff of higher sand ridges, but farther south it passes to a strong wave-cut bench from 100 to 200 yards wide with a steep cliff 50 to 100 feet high (Fig. 1). Upon this bench, the most striking development of the Nipissing beach upon the island, a dune

ridge 20 to 50 feet high has been built up and in some parts strengthened by a grassy fore-dune. The ridge is completely fixed and was evidently formerly covered by a mesophytic forest of maple, beech, and hemlock, with a small amount of *Abies balsamea, Picea canadensis,* and *Populus balsamifera* at the outer edge. This has been cut off, and the dune cover now consists of a few remnants of trees and coppice from the former forest, together with such pioneers as *Betula alba papyrifera, Prunus pennsylvanica, Populus grandidentata, Ostrya virginiana* and *Acer spicatum.*

A most distinctive shrub association has developed upon the gravel of the Nipissing beach as well as upon the low dunes which are developed before or are percehd upon it. It occurs both upon High and Beaver Islands, and is characterized by low growth, small thick leaves, a large amount of vegetative propagation from buried stems and by a decided scarcity of grasses. On Beaver Island a scanty sprinkling of *Agropyron dasystachyum* is almost the only grass present, but on High Island there are in addition small amounts of *Ammophila arenaria,* and *Calamovilfa longifolia.* The effect of exposure to the strong winds of the west and south-west seems to be the cause of a decided dwarfing in all the larger shrubs. Species that upon other dune habitats attain a height of 3 to 6 feet or even more are here reduced to a foot or less. *Prunus pumila, Cornus stolonifera* and *Salix* spp. afford examples of such dwarfing except when they occur within the shelter of the succeeding border zone of forest. The same thing is true of *Populus balsimifera* which is seldom more than a yard high among the shrubs, although it occurs rather freely within that association.

The composition of this association varies somewhat, although generally its dominant members are *Arctostaphylos Uva-ursi, Prunus pumila, Salix longifolia, S. syrticola, Populus balsamifera,* and in some localities *Potentilla fruticosa* and *Cornus stolonifera.* With these broad leaved shrubs *Juniperus horizontalis* and *J. communis* mingle freely and in places become dominant with the gradual elimination of the willows, cherries, and poplars. Either the broad or needle leaved shrubs may be succeeded by the trees of a marginal shore forest

in which *Populus balsimifera, Betula alba papyrifera, Abies balsamea, Thuja occidentalis* and *Picea canadensis* are most abundant. On the more open portion of these low dunes there are mingled with the shrubs such herbaceous plants as *Artemisia canadensis, Cirsium Pitcheri, Zygadenus chloranthus* and *Lithospermum Gmelini.*

HIGH PERCHED DUNES

The rapid erosion along the east shore of Lake Michigan has developed many stretches of steep shore cliffs cut in the

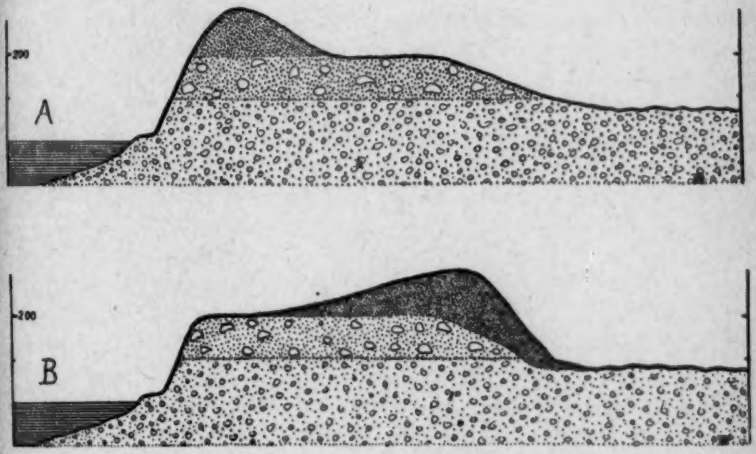


Fig. 2. Diagramatic east-west cross sections through a shore cliff near Frankfort, Mich., showing stratified clays and gravels upon which is perched a sand dune. Vertical height in feet at the left of diagram. Horizontal scale one-half the vertical.

morainic material. These cliffs very much in height and are frequently surmounted by dunes of considerable size. Only a few of the most notable of those recently examined are here described.

A half mile north of Frankfort the eroded shore shows distinct stratification of morainic clays and gravels while upon the moraine there is perched a dune, the top of which, according to the maps of the U. S. Lake Survey, reaches the height of

320 feet above the lake, about 100 feet being sand (Fig. 2A). This dune area is about half a mile long and about half that width, and has recently been mapped and described by Waterman[2]. The upper stratum of morainic material is largely composed of boulder clay, giving when eroded a number of "razorback" cliffs. The dunes have been fixed and forested but through them has cut a complex of wind-sweeps ending in a semicircular blow-out popularly known as "The Crater" (Fig. 2B). The wind-sweep throughout the greater part of its channel has cut quite through the sand and has exposed the surface of the morainic plateau. The sand of which this perched dune is composed may well have been derived from the waters of the former Lake Algonquin, although there is nothing to show that they are not of terrestrial origin. In this connection it may be recalled that the moraine upon which the dunes are perched are at least 150 feet above the supposed level of Lake Algonquin or of the Nipissing Great Lakes.

A second example of even more remarkable perching is found four miles north of Empire in the Sleeping Bear dunes. Here the morainic substratum is in the form of a kame-like ridge with its long axis parallel to the Lake Michigan shore and its flat top about 400 feet above the lake. At the north and east of this plateau the gravelly surface is much lower, while an east-west section through the ridge just north of "The Bear" shows that a peak (Fig. 3A) of gravel near the eastern side projects above the sand which has been swept from the plateau and is moving towards the east. That the greater part of this plateau was formerly well covered with perched dunes is evidenced by the great banks of sand on the west side where they present a great advancing lee front over a mile long with a maximum height of over 300 feet (Fig. 3A). Upon this wind swept plateau the most conspicuous dune remnant, perched on the edge of the shore cliff, is the isolated mound some 90 feet high and four times as broad, known as the "Sleeping Bear" (Fig. 3B). The north and east slopes are still well covered with the remnants of a mesophytic forest in which *Thuja occidentalis, Sorbus americana, Acer saccharum* and *Tsuga canadensis*

[2] Waterman, W. G. Ecology of Northern Michigan dunes: Crystal Lake Bar region. Rep. Mich. Acad. Sci. 19: 197-207. 1917.

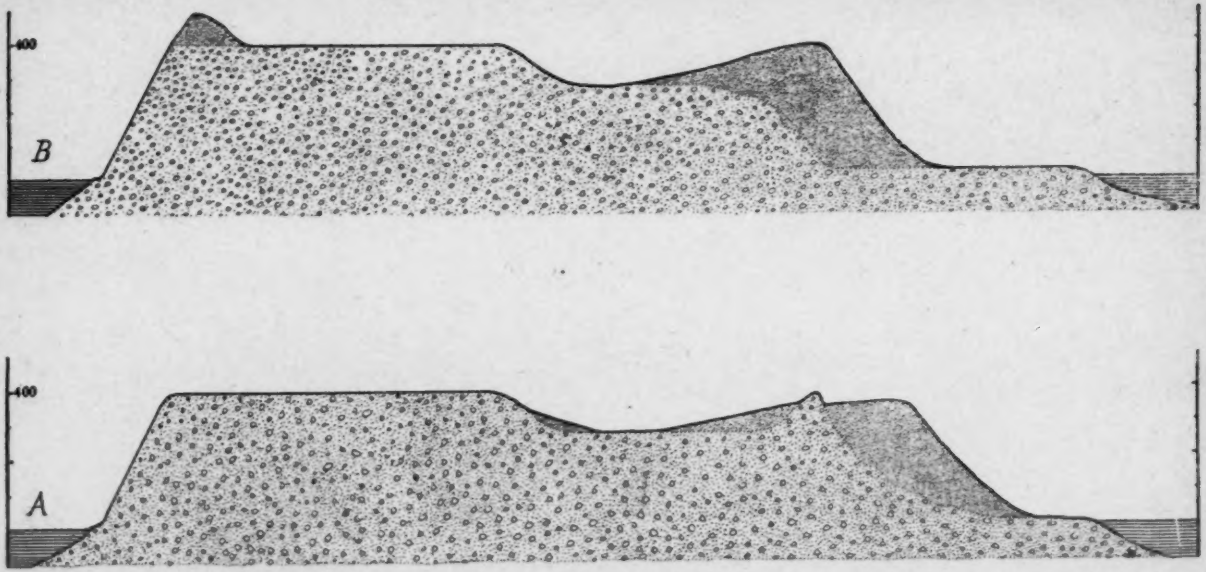


Fig. 3. Diagramatic east-west cross sections through the kame-like gravel ridge and the perched dunes at Sleeping Bear Point, ich. The section extends from Lake Michigan on the left to Glen Lake on the right, section *A* being just north of the Sleeping Bear Dune and section *B* directly through the Sleeping Bear Dune. Vertical height in feet at the left of diagram. Horizontal scale one-half the vertical.

are conspicuous. The other sides are being eroded but show signs of having been covered with forest.

It seems quite probable that dunes of the size of Sleeping Bear or even larger could have been formed at the top of a high shore cliff, but it is difficult to imagine that the great mass of sand that has been swept from the morainic plateau and forms the great moving dune advancing towards the east could have been so brought up from the lake at least 300 feet below. The hypothesis of a terrestrial origin for the sand would on the contrary seem more suited to explain the situation if it could be supported by adequate data. Such data have not been obtained in the Sleeping Bear area but appear upon one of the islands to the north.

South Fox Island, lying in Lake Michigan about 35 miles north of Sleeping Bear Point is about 5 miles long and a fourth as wide, the long axis of the island running some 30° west of north. The chief topographical features are a continuous ridge of morainic material capped with dunes, varying from 200 to 325 feet in height, and from 200 to 400 yards in width, running along the western side and a gravelly plain of low elevation which occupies the eastern side of the island (Fig. 4A).

The western shore is being rapidly eroded and the cliffs rise abruptly from a very narrow beach strewn with pebbles and glacial boulders. The cliffs are composed of mixed morainic clays and gravels while a distinct horizontal line separates the lower more stony mass from the upper more sandy material. This line has an elevation running from about 125 feet at the south of the island to somewhat more than 200 feet at the north. This upper stratum of sandy material has been somewhat worked over by the wind and at least one large wind sweep has developed, the trough being floored with glacial gravel and the whole terminating in a bald dune, about 325 feet high, forming the highest elevation upon the island (Fig. 4B). Much of the sandy stratum, however, presents evidence of having been deposited by agencies other than wind. The evidence consists in an admixture of pebbles, bits of rock, and particles of soil both larger and smaller than the grains of wind-blown

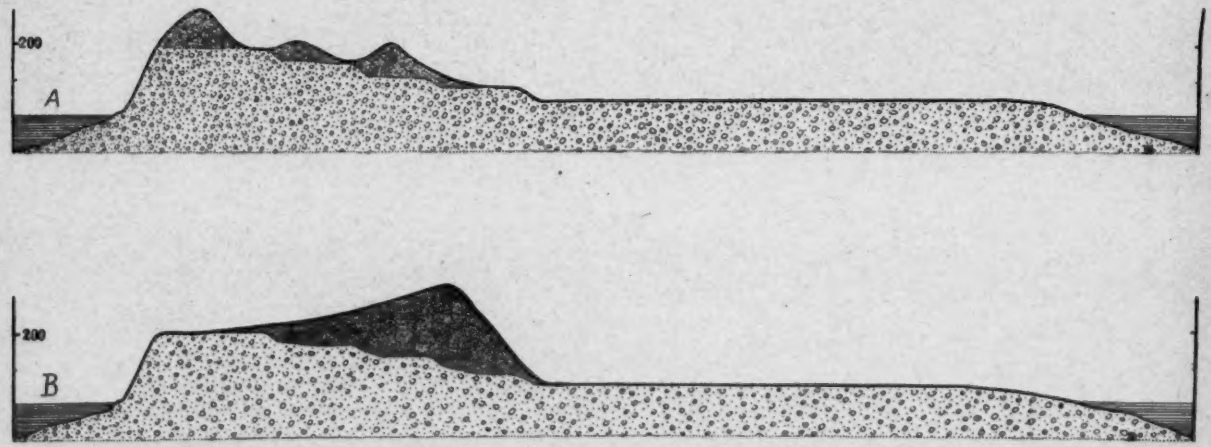


Fig. 4. Diagramatic east-west sections through South Fox Island showing gravel ridge and perched dunes. Vertical height in feet at the left of the diagram. Horizontal scale one-half the vertical.

sand. It seems most probable that this sandy soil was deposited simultaneously with or immediately following upon the formation of the kame-like ridge upon which it rests, and that it is due to similar combined action of ice and water. The exact method of its deposition may be more definitely explained upon further investigation, the main point of interest at the present time, however, is that the sandy mounds which cap the ridge are not composed of lacustrine sand piled up by the wind, but have an origin connected more immediately with the former ice sheet. It is evident that this material being largely sand and lying in an exposed situation has been subject to disturbance and working over by the wind. Dunes have been and are being formed from it and these dunes may be termed terrestrial in origin.

If it be granted, as the evidence seems to demand, that these perched dunes of Fox Island are terrestrial, it seems highly probable that many of those of the Sleeping Bear area had a similar origin, for the topography of the two regions is so extremely similar. The large mass of material in the advancing dune swept from the plateau upon which the Sleeping Bear dune rests would present no difficulty when explained by the hypothesis of terrestrial origin.

Without extensive investigation it is impossible to say just how many of the sand hills upon South Fox Island are dunes and how many are made up of glacial sands. It is certain that the high bald dune in the center of the island is composed of wind-blown material and is still slowly moving across the island, but it seems highly probable that many of the peaks which immediately surmount the shore cliff were, in their deposition, intimately related to some phase of glacial activity. The hills at the east of the shore ridge probably are in part dunes, and in part glacial sand hills, the two showing no difference in plant covering.

The variations in the plant associations of the various dune regions mentioned will be discussed elsewhere but it seems worth while to call attention to the climax mesophytic forest as developed upon the sand hills of South Fox Island. Although less than 25 miles from the mainland, where these species

abound, the island is entirely without any *Pinus* or *Tsuga* nor was any *Acer pennsylvanicum* seen. *Salix* spp. were also represented by very few individuals, as were also *Picea canadensis* and *Quercus rubra*.

The mesophytic forest has covered all but a very few of the highest peaks and doubtless formerly extended over all the plain which forms the eastern half of the island. Less than 100 acres of the island have been completely cleared and cultivated, but more than three-fourths of its surface has been more or less cut over although there is little evidence of damage by fires. The higher hills being less easy of access, have had less of their timber removed and are covered with a rich growth of *Acer saccharum, Thuja occidentalis, Fagus grandifolia, Abies balsamea,* and *Tilia americana,* the three first being most abundant, the *Acer* dominating the gentler slopes and the *Thuja* the narrow valleys and steeper hillsides. Occasional trees of *Betula luta* and *Fraxinus americana* are found and where cutting has occurred *Betula alba papyrifera, Populus grandidendata* and *Prunus pennsylvanica* have come in. Among the shrubs are *Sorbus americana, Sambucus racemosa,* and *Taxus canadensis,* the latter being particularly abundant, while among the herbaceous vegetation were found such decidedly mesophytic forms as *Trillium declinatum, T. grandiflorum, Hepatica triloba, Actaea alba, Mitella nuda,* and *Mitchella repens.* Perhaps the most conspicuous fern was *Cystopteria bulbifera,* but *Botryhium virginianum, Aspidium marginale* and *A. spinulosum* were also fairly abundant.

In concluding, it may be mentioned that a similar mesophytic forest with *Thuja* as a conspicuous member is to be seen along the marginal shore dunes at Frankfort, while "forest graveyards" of *Thuja* upon the dunes of the Sleeping Bear complex as well as the remnant of forest upon Sleeping Bear dune itself would serve to indicate their former development in that region.

The writer wishes to acknowledge the courteous criticisms of Messrs. Frank Leverett and F. B. Taylor who were good enough to read his manuscript. He also wishes to state that

he assumes full responsibility for certain portions of the paper that are not entirely in accord with the views of these distinguished critics.

LOCAL INCLUSIONS OF PRAIRIE WITHIN FOREST

ARTHUR G. VESTAL, EASTERN ILLINOIS STATE NORMAL SCHOOL, CHARLESTON

The accounts of early settlement in Illinois and neighboring states mention frequently the occurrence of small openings or glades in the forest, covered with prairie vegetation. Probably most of them were small patches of upland prairie, surrounded by xerophytic oak forest which had slowly spread from nearby stream valleys. These small prairies, and most of the forest which surrounded them, are now destroyed by cultivation. But there may also have been prairie openings of a second type, which because of their small size and scattered distribution, have escaped notice, and are practically unknown today, although they are still fairly numerous. Probably they would be regarded as mere open places in the woods, without being recognized as prairie. These small prairie inclusions were first noted in 1916 in the neighborhood of Charleston. It is generally known that at the present time forest tends to encroach upon treeless areas where cultivation does not prevent, but it is not generally known that in many places local exceptions to this tendency may be found. Probably the greatest interest which these prairie inclusions may claim lies in the fact that many of them seem to be holding their own against forest invasion, and that in places prairie vegetation has even replaced forest, in recent years.

The commonest topographic site for these small areas of prairie is the windward crest of a valley or ravine running down to the east, southeast, or south, and the side-slope beneath which accordingly faces to the south, southwest, or west. The essential condition is the great insolation and exposure to the dry summer winds from the south and southwest, making for local xerophytism. This is apparently a static rather than a dynamic feature of the environment, since both habitat and

xerophytic vegetation may persist indefinitely, even though there is a slow lateral migration as the valley widens. It is probable that the dryness occasioned by the slope to the south is in most places not in itself sufficient to preserve the prairie from forest encroachment, for forest is able to establish itself in quite xerophytic habitats in the vicinity, and has in fact done so over most of the south-facing ravine slopes. Other physical factors aid the original exposure afforded by direction of slope. One is instability of surface, due partly to steepness, partly to the meagerness of protection against erosion afforded by the open and sparse ground-cover.* Others are accidental and artificial factors which destroy or check forest growth, such as fire, cutting, grazing, and trampling. These operate in places only temporarily, but in other places recur frequently enough to permit the continued existence within the forest of small but rather numerous patches of prairie, with more or less shifting boundaries, wherever the basic condition of southward exposure is fairly extensive. The spur-tops and other small upland areas adjoining the slopes may also show prairie vegetation, especially in those ends and corners of uplands which are too small or too narrow to tempt the farmer to invade them with the plow, even if there are no trees. This type of situation is a distinct geographic or topographic entity and should have a name. *Upland salient* or simply *spur-top* might answer this need.

The locality which shows these local prairie inclusions best is hardly more than a mile east of the southern part of Charleston, along a large ravine ("Endsley's ravine" or "Endsley's Hollow") which runs east and a little south to the Embarras river. A topographic map showing some of these patches of prairie was made so that situation and extent could be quite definitely shown (Fig. 1). Most of the prairie is below the crest

*It is of interest that even in flat areas like east-central Illinois, the topographic diversity of the broken country of the valley-slopes and ravines results in vegetation-diversity, in a manner entirely comparable to that which prevails over the general area in a mountainous region. Thus in the rock exposures along the Embarras river three miles east of Charleston, and in the various slopes and valleys of the district, there can be found many of the types of physical habitats common in mountain areas. One thus can learn much of the relations of topography and vegetation as developed in mountains without visiting the mountains themselves.

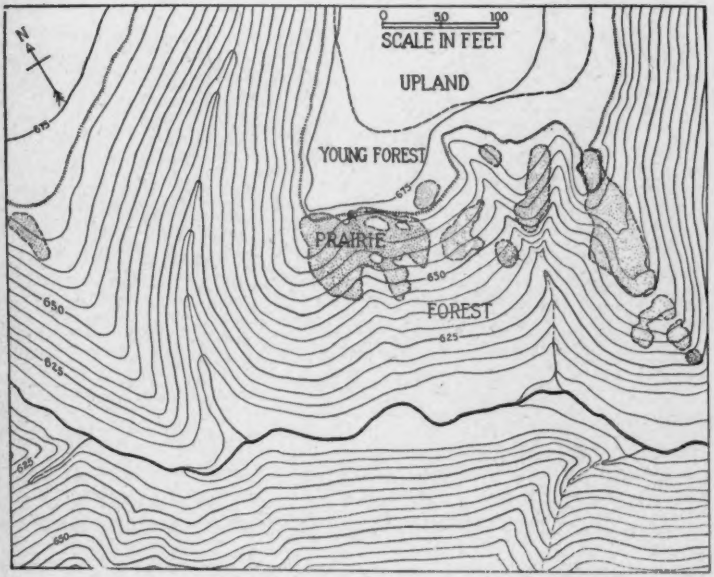


Fig. 1. Map of a ravine area with prairie inclusions, near Charleston, Illinois.

Fig. 2. Part of the largest patch of prairie shown in map. Leaves of Silphium in foreground.

Fig. 3. A very small opening about 15 feet across, near Embarras river, almost entirely enclosed by forest. Grapevines on trees, border of sunflowers at right and in back. Silphium, Parthenium, and several prairie grasses are found even in some of the smallest patches.

Fig. 4. Andropogon furcatus in gravelly clay on spur overlooking Embarras. The treeless area is about 15 feet on either side of the trampled path, and there are numerous prairie species.

or edge of the upland, shown by the line of short hachures. Forest had at one time spread about a quarter-mile from this edge, and had since been cleared for cultivation. New forest growth near the edge has come in since about 1911. Prairie and forest herbs occur in mixture in open spaces between saplings. The largest prairie patch has almost luxuriant vegetation, in which grasses, and Parthenium integrifolium, and the coneflower Brauneria purpurea, are conspicuous. There are also a few long-lived perennials, such as Silphium terebinthinaceum (Fig. 2), which are commonly absent from prairie that has not been established for many years. The invasion of forest seems to be upward, because the shade falls on the part of the slope just above the position of the trees. The boundary between prairie and forest vegetation is in places somewhat ragged and indefinite, partly because prairie and forest herbs intermingle along the border, where also occur the forest-border sunflowers, Helianthus strumosus and H. divaricatus (Fig. 3), and the bushy legume Baptisia leucantha, and the half-shrub Ceanothus americanus. The badly washed spur at the right in the map is mostly bare clay with scattered bunches of Andropogon scoparius, and a few interstitial annuals, including two small species of Lespedeza, which are typical in new growths of clay hillsides. The taller bunch-grass Andropogon furcatus is common in places (Fig. 4). A long, narrow spur-top just east of the area mapped is covered with prairie of apparently recent development from forest.

Small prairie patches in the woods are common also along the Embarras river, especially on the south-facing flanks of spurs, on both sides of the stream. Figures 3 and 4 illustrate two of these patches. One extensive south-facing hillside, once forested, is now part of a large pasture. Many kinds of prairie plants persist on this hillside, due to the topographically determined dyness and instability of soil, which keep the blue-grass from driving out the native plants, as it does in level or in well-watered pasture.

In conclusion, it appears that these small enclaves or openings of prairie in forest must be of fairly general occurrence, that they deserve to be generally known, and some of them set aside as natural history preserves. They illustrate admirably

the influence of topography in control or modification of vegetation-distribution and vegetation-development. They show that while forest invasion of prairie is general, it is by no means universal.

INVASION OF FOREST LAND BY PRAIRIE ALONG RAILROADS

ARTHUR G. VESTAL, EASTERN ILLINOIS STATE NORMAL SCHOOL, CHARLESTON

The Big Four, Clover Leaf, and other railroads in central Illinois, in crossing the numerous and generally forested stream valleys, make treeless paths through many wooded areas. The rights of way in these cleared areas become vegetated from nearby plant populations, which are of three types, forest, prairie, and ruderal. The forest immediately adjoins these cleared areas, and would in most cases quickly reproduce itself if the railroad companies would allow seedling trees to reach tree size, which they do not. However, many forest herbs and certain forest shrubs, including sumac, blackberry, hazel, and Symphoricarpos, make up the dominant vegetation in such places, especially on the east side of streams, where the forests are more extensive, having there been well protected from former prairie fires, as shown by Gleason.

Certain other cleared parts of the rights of way are not far from areas of prairie vegetation, and have received abundantly the seeds of prairie as well as forest plants. In numerous small areas one finds mixed communities of prairie and forest herbs. It is probable that these mixed growths may in places be relatively enduring. The new growths of mixed forest and prairie plants which must have followed the original felling of the trees were probably unstable, as many of them now are. Their development either into forest growth minus the trees or else into typical prairie, probably depended, as it does now, upon a number of factors. Among those which favor the development into prairie are: coarse well-drained soil; considerable exposure to wind and sun, as presented by certain topographic situations; deficiency of rainfall during one critical or several successive growing seasons; and the destructive effects of burning or of mowing, both of which are common on rights

of way. The opposites of these influences would favor development into forest.

The ruderal plants are in too many places able to get in and successful in establishing themselves, forming pure weed growths or ruderal components in forest or prairie.

The forest clearings most likely to be successfully revegetated by prairie plants are those to the west of streams, since there the prairie is better preserved, and the forest fringe is narrower and broken. The right of way approaches a stream on a down grade through broken country dissected by ravines. In

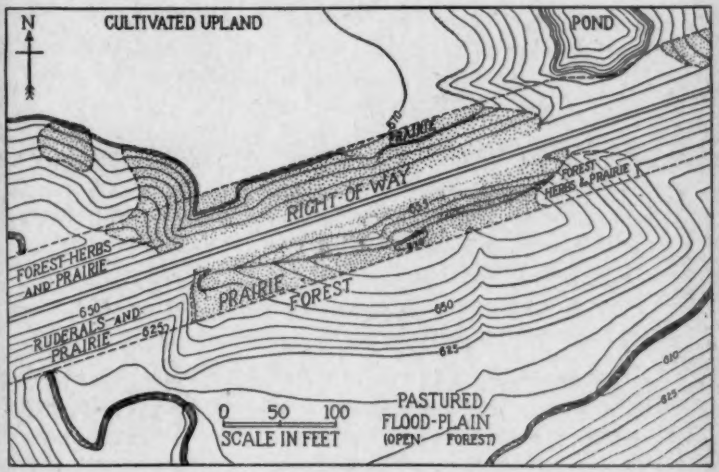


Fig. 1.

most places the original boundary between prairie and forest on the west side of streams was at or near the edge of the flat upland, but there were usually tongues or islands of prairie even in the broken country near the stream, within the general forest area. These have spread into the rights of way, occupying them almost continuously from the prairie upland to the end of the embankment which runs to or part way over the flood-plain, thus making a narrow lane of prairie through the forest. In a few places it appears that prairie vegetation is established on the east side of the stream as well.

A sample area in the broken country a quarter-mile west of the Embarras river was mapped (Fig. 1). The originally forested area, much of it still wooded, extends a third of a mile west of this area. The upland shown was probably entirely forested; it is now a cultivated field. Its steep southwest and west side-slopes are partly forested; there are rather well-developed patches of prairie also, and prairie plants among scattered trees. The Big Four railroad makes a cut eighteen feet deep through the end of this upland, and its right of way is now all prairie, both over what remains of the original surface and on the steep clay banks of the cut. Of the numerous prairie species, Andropogon furcatus, Brauneria pallida, Parthenium integrifolium, and Euphorbia corollata, are conspicuous. The hillside just over the fence from the prairie in the right of way is closely covered with trees; the boundary at the fence is quite sharp.

North and northeast-facing slopes in the right of way have the mixture of prairie and forest herbs previously mentioned. Notable plants are Smilacina (two species), Polygonatum, Taenidia integerrima, Specularia, Gillenia stipulata, and in one station, Pteris aquilina.

If the prairie growths remaining along railroads are to be of use as typifying former conditions of prairie vegetation, care must be taken to distinguish areas of original prairie from those recently developed on forest land. The rather frequent occurrence of such new growths, established as they seem to be, makes it necessary to reconsider the fairly common notion that prairie vegetation, once destroyed, is gone forever, and to realize that in its struggle for survival against cultural, ruderal, and forest plants, the prairie, in some areas at least, is putting up a not altogether losing fight.

PLANT SUCCESSION ON AN ARTIFICIAL BARE AREA IN ILLINOIS

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The opportunities that botanists have had for studying the revegetation of bare areas of great extent have been few. The island of Kracatoa, laid bare by its volcanic explosion in 1883, has become a classic example. The Salton Sea area in southern California which is being so carefully studied by Dr. D. T. MacDougal and his collaborators bids fair to become as great a classic. The region laid bare by the eruption of Mount Katmai in Alaska, which is being made famous by Dr. R. F. Griggs, is a still more recent example. But this nearly completes the list. It is, therefore, of interest to note that we have in Illinois several bare areas of no mean proportions some of which are being left for nature to reclothe.

The areas to which I refer are those bottomland areas that have been "stripped" by coal mining companies in the practice of surface mining. Aid received from the Illinois State Laboratory of Natural History enabled me to make several visits to the properties of the Missionfield Coal Company, situated about five miles west of Danville, Illinois, during the summer of 1917. These properties which cover some thirty or forty acres are of special interest because they consist of three distinct sections which were worked at different times and therefore represent different stages of revegetation.

The area under consideration was originally covered with the bottomland forest characteristic of the region in which the sycamore is one of the dominant trees. This vegetation was all destroyed of course by the operations of the mining company and the land was left as a bare area consisting of alternating ridges, and furrows, the ridges varying from three or four feet to twelve or fifteen feet in height. I am indebted to Mr. W. G. Hartshorn for information concerning the time that has elapsed since the various parts of the area were worked by the coal company. The facts brought out by him are that the east section was operated about eighteen years ago and the middle

section about three years later, while work on the west section was started about six years ago and finished four years later.

The west section because of its recent abandonment is still largely occupied by the pioneer ruderal plants. Because of the nature of the surface (Fig. 1) both hydrarch and xerarch secondary successions are represented. In the bottoms of the furrows the two knotweeds, Polygonum aviculare and Polygonum persicaria, are the dominant and often the only plants. In the shallower furrows Echinochloa crusgalli, the barnyard grass, takes the place of the Polygonum or occurs along with it, and often scattering individuals of the giant ragweed, Ambrosia trifida, also are present.

The ridges present somewhat more variety in heir floras although some of them are almost exclusively occupied by the sweet clover, Melilotus alba. Others, however, are covered with such plants as the wild aster, Aster ericoides; sunflower, Helianthus hirsutus; ragweed, Ambrosia artemisiifolia; evening primrose, Oenothera biennis, and occasional individuals of black mustard, Brassica nigra. On those parts of the section that have been longest abandoned one finds also patches of venus's looking glass, Specularia perfoliata, and of partridge pea, Cassia Chamaecrista, and occasional individuals of pokeweed, Phytolacca decandra.

The middle section of the area under consideration has been subjected to artificial interference which has not made it less interesting but has greatly retarded its revegetation. The interference is due to the fact that the mining company is almost constantly pumping water into it so that it is largely flooded as shown in Fig. 2. The shallow parts of the water are occupied almost exclusively by the cat-tail, Typha latifolia. Just above the water on the sides of the ridges there is usually a zone of cocklebur, xanthium commune. On some of the lower ridges the willow, Salix nigra, has become established in considerable numbers, while the higher ridges are in most cases still occupied by sweet clover, melilotus alba, and black mustard, Brassica nigra.

In the eastern section the xerarch and hydrarch successions mentioned in connection with the western section have become

Fig. 1. The west section of the Missionfield Coal Company grounds showing the alternating ridges and furrows which result from "stripping" the coal. Ruderal vegetation be-

Fig. 2. The middle section of the Missionfield Coal Company. Explanation in text.

Fig. 3. The east section of the Missionfield Coal Company. The larger trees are cottonwoods.

merged into one, and we find the vegetation well on its way toward the re-establishment of the bottom-land forest (Fig. 3). The trees consist of the willow, Salix nigra, which was probably the first to appear; the cottonwood, Populus deltoides, which occurs up to eight inches in diameter; soft maple, Acer saccharinum; red elm, Ulmus fulva, and sycamore, Platanus occidentalis, the last three all being small. The undergrowth is such as would be expected in such a situation and need not be described here.

As previously stated eighteen years have elapsed since this eastern section was abandoned by the mining company. Since numerous small individuals of the sycamore, one of the very characteristic bottomland trees, are already present it is probable that twenty-five or thirty years will be sufficient for the complete re-establishment of the typical bottomland forest.

ON THE FOLIAR TRANSPIRING POWER OF TILIA

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ABSTRACT

Studies on the foliar transpiring power of *Tilia* were conducted during the summer of 1916 and 1917 in the dune area of northern Indiana. *Tilia* was chosen because of its unusual ability to surmount the dunes which move upon and cover large areas of mesophytic forest. In fact it is the only tree representative of the forest which displays this ability to any degree.

Five stations were selected which represented gradations in habitat; Station A. was located in a forested dune area which had become completely stabilized and contained an abundance of herbaceous undergrowth and considerable humus. Station B. was chosen at a point near the edge of the forested dune and was partly exposed to the wind. Station C. was at the very edge of the forest and was also located at the edge of a blowout where the humus had been largely removed. Station D. was on the lee side of an advancing dune where the exposure, especially to the sun, was very great, and where there was no humus. Station E. was situated at the top of a high dune which was

exposed to wind from all directions, and to the sun throughout the day. This represented the most xerophytic type of habitat available upon the dunes.

Transpiration readings were recorded by means of the cobalt chloride hygrometric paper. Correlative readings were taken of atmospheric temperature, relative humidity, direct evaporating power of the air, soil moisture, soil temperature, and wilting coefficient. These were measured that the true relation of the relative mesophytism of the stations might be better understood, and that their relation to the foliar transpiring power might be expressed.

It was found that the transpiring power at station A. was less than that of any other station, and the water loss at station E. was the greatest. Stations B, C, and D, showed an increase over A. which was directly proportional to the increase in xerophytism.

Transpiration was most rapid at the stations where the lowest average soil water and the most xerophytic leaf structures were found.

It was discovered that the amount of soil moisture had no appreciable effect upon the transpiration stream except when the wilting coefficient of the soil was approached.

Light, wind, and relative humidity were the factors which most strongly influenced the fluctuation of the current. The transpiration index was found to rise very rapidly just after dawn, and more rapidly upon the open sands than in the shaded forest.

A "saturation deficit" was developed in most instances and was much more in evidence upon the open dunes than in the forest. In fact in the forest the deficit did not appear in many of the readings, especially when the day was cloudy and the relative humidity high.

Although the saturation deficit was very strongly developed upon the open sand, there was never any visible evidence of wilting there. In the early summer the soil water content in

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*A more extended report of the work on Tilia appeared in Bot. Gaz. 68: 262-286. 1919. "Comparative Studies of the folia Transpiring Power."

the forest was much greater than that of the open dune areas, but in the fall visible wilting became evident in the former of these situations where it was found that the water had been reduced to the wilting coefficient. This was evidently due to the presence of a vegetation so abundant that its demands for water could not be met by the sand which holds a much smaller amount of available water than any other type of soil. Further evidence of this was noticed upon the open sand where there was no visible wilting at any time. Although the available water for plant growth is always low there, the dmand made upon it is of course almost negligible because of the sparcity of plant growth.

More rapid water loss upon the open sand as compared to the low rate for the forest, was quite different from the findings of previous investigations made upon desert plants by Bakke,[1] Livingston, and Shreve.[2] These investigators report a very low index for the various desert xerophytes studied. In fact the first named author has suggested as a criterion for the mesophytism of a plant its foliar index of transpiration; and in the suggested scheme the mesophyte should show the highest index and the xerophyte the lowest. Intergradations in the scale would indicate different degrees of mesophytism. Yet in the work upon *Tilia* it was found that such an application would prove misleading because the transpiration current is very much greater in the most xerophytic habitat than in the established dune forest which is certainly the most mesophytic of the five situations, and the leaf structure in the former of these habitats is undoubtedly much the more xerophytic.

It will be recognized, however, that the situation in the case of *Tilia* is different from that in the investigations of the above named authors.

They were invstigating transpiration of certain xerophytes which were growing in their normal environments. This is rather an instance of a species making a rapid correlation to a forced environment; and although the assumed xerophytism

[1] Bakke, A. L. Studies on the Transpiring power of plants as indicated by the method of standardized hygrometric paper. Jour. Ecol. 2: 145-173. 1914.

[2] Livingston, B. E., and Shreve, Edith B. Improvements in the methods of determining the transpiring power of a plant surface of hygrometric paper. Pl. World. 19: 287-309. 1916.

of leaf structure is indicative of considerable plasticity, yet the correlation in structure has not been proportional to the variation in environment, from a normal mesophytic to an abnormal xerophytic one. In other words the response to external influence lags behind the causal factors to a considerable degree.

ARTIFICIAL KEY TO THE WEED SEEDS FOUND IN COMMERCIAL SEEDS IN ILLINOIS AND ADJOINING STATES

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INTRODUCTION

The purpose of this work is to aid one to determine the weed seeds and seed-like-fruits frequently found in commercial grains of Illinois and adjoining states. The term, seed, in this key, is used to mean a ripened ovule. It is not used to include fruits such as an achene and caryopsis. If the structure is a fruit, it is named as such.

Since the terms seed, fruit, achene, caryopsis, nut, nutlet, utricle, spike, spikelet and involucre are used, it is necessary to define them. A seed is a ripened ovule; *e. g.*, wild mustard. A fruit is a ripened ovary with its attachments; *e. g.*, common ragweed. An achene is a seed-like indehiscent fruit in which the seed is not firmly united with the wall of the ovary; *e. g.*, curled dock. A caryopsis is a similar one seeded indehiscent fruit in which the seed is firmly united with the wall of the ovary; *e. g.*, cheat. A nut is a dry indehiscent fruit usually one celled and one seeded, with a hard bony wall; *e. g.*, hazelnut. A nutlet is a diminutive nut; *e. g.*, wheat thief. A utricle is a small one seeded dry fruit with a thin bladdery loose ovary wall. When ripe the wall bursts and the seed is exposed; *e. g.*, lamb's quarters. A spike is a form of inflorescence with the sessile flowers arranged on an elongated common axis; *e. g.*, wheat. A spikelet is a small or secondary spike. It may consist of a one seeded fruit, caryopsis, enclosed by coverings, which are scale-like, called lemma, palea, and outer lumes; *e. g.*, yellow fox-tail. An involucre is a cluster of small leaves or bracts just below the flower. It may be modified and enclose an achene; *e. g.*, common ragweed.

The seeds and seed-like fruits were gathered during the years of 1916 and 1917 in Champaign County, Illinois. By examining commercial seeds obtained from seed houses, by getting expressions from various seed-dealers, by consulting bul-

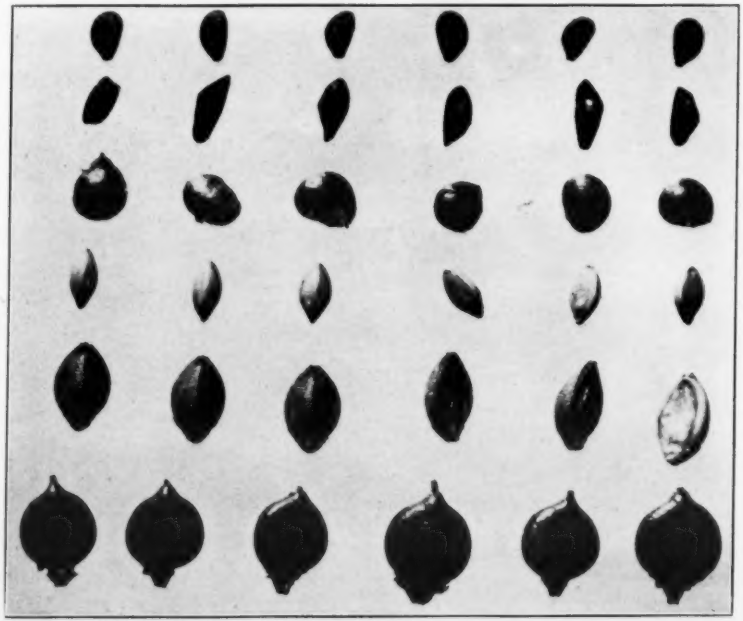
letins and other literature which list troublesome weed-seeds in grains, and by the writer's experience with weed-seeds on the farm, the thirty-one seeds and fruits, which make up the key, were selected.

The descriptions have been made with the use of a lens which magnifies about ten diameters. A simple lens known as "linen tester" gives very good results. Photographs show seeds and fruits magnified four diameters. Descriptions were made and photographs taken of the fruits after they were rubbed between thumb and forefinger. The nomenclature and order of classification are those of Gray's New Manual of Botany, seventh edition, 1908. When other names are used in common manuals they are placed in parenthesis.

Two previous weed-seed keys have been made. One by Edgar Brown and F. H. Hillman, keying the seeds of six species of Poa as found in commercial seeds. "The Seeds of the Blue Grass" Bulletin 84 of Bureau of Plant Industry, U. S. D. A. The other by E. L. Palmer in which he makes a seed key to some common weeds and plants. "A Seed Key to some Common Weeds and Plants," Iowa State Academy of Science, 1916. The work was done under the direction of Professor William Trelease of the Botany Department of the University of Illinois. The writer desires to acknowledge the many helpful suggestions received.

The Key

1. Terminal appendages present. 2.
   Terminal appendages absent. 4.
2. Appendages stiff, spiny; fruit top-shaped. Ambrosia artemisiifolia.
   Appendages scale- or bristle-like. 3.
3. Achene with 2 rows of scales at apex. Cichorium Intybus.
   Achene with a whorl of short bristles at apex. Erigeron annuus.
4. Seeds shot-like. 5.
   Seeds or schemes not shot-like. 6.
5. Seeds black, surface scarcely raticulated. Brassica arvensis.
   Seeds brownish, surface distinctly reticulated. Brassica nigra.



Row 1. Lepidium virginicum.

Row 2. Plantago Rugelii.

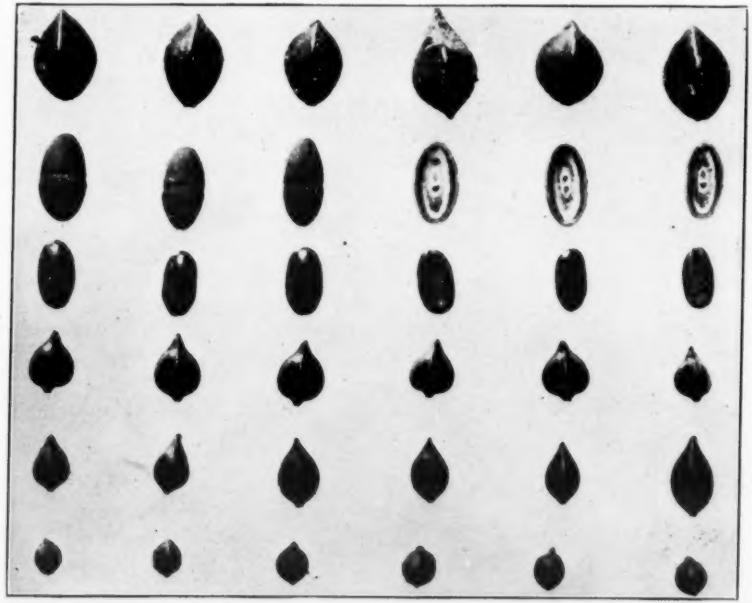
Row 3. Solanum carolinense.

Row 4. Setaria viridis.

Row 5. Setaria glauca.

Row 6. Polygonum pennsylvanicum.

PLATE I.



Row 1. Polygonum Convolvulus.

Row 2. Plantago aristata.

Row 3. Plantago lanceolata.

Row 4. Rumex crispus.

Row 5. Rumex obtusifolius.

Row 6. Rumex Acetosella.

PLATE II.

6. Triangular in cross section. 7.
   Not triangular in cross section. 10.
7. Achene black, granular, angles rounded. Polygonum Convolvulus.
   Achene brown. 8.
8. Achene attenuate at apex. 9.
   Achene not attenuate at apex, 1 to 1.5 mm. long. Rumex Acetosella.
9. Achene shiny, 1.5 to 2.5 mm. long. Rumex crispus.
   Achene not shiny, 2 mm. long, acuminate. Rumex obtusifolius.
10. Canoe shaped. 11.
    Not canoe shaped. 12.
11. Convex side with groove across the middle. Plantago aristata.
    Convex side not grooved. Plantago lanceolata.
12. Surface sculptured. 13.
    Surface not sculptured. 17.
13. Surface granular. 14.
    Surface otherwise. 16.
14. Achene jet black, flattened. Polygonum pennsylvanicum.
    Seeds not jet black. 15.
15. Reddish to yellow, flat, two-thirds ovate. Lepidium virginicum.
    Brown to black, coarsely granular. Plantago Rugelii.
    Lemon yellow, slightly double convex. Solanum carolinense.
16. Achene having vertical stripes. Cirsium lanceolatum.
    Surface having vertical lines. Digitaria sanguinalis.
    Achene having vertical spotted ridges. Lactuca scariola.
    Achene having warty ribs, obovoid. Anthemis Cotula.
    Seed coiled, conical. Salsoli Kali.
    Seed with 3 to 6 curved rows of tubercles.
        Seed brownish, flattened. Stellaria media.
        Seed lead colored, .5 mm. in diameter. Silene antirrhina.
    Seed wrinkled, base white-tubercled. Lithospermum arvense.

Caryopsis inclosed with scales having transverse striations.

Straw colored, striations branched. Setaria glauca.
Green, striations faint. Setaria viridis.

Seed minutely pitted, ovoid to spherical. Cuscuta arvensis.
Seed with faint radiating striations. Chenopodium album.

17. Lens shaped. 18.
Not lens shaped. 19.

18. Seeds circular, .7 to .9 mm. Amaranthus graecizans.
Seeds obovate, 1 to 1.2 mm. long. Amaranthus retroflexus.

19. Groove on one side, grain reddish brown. Bromus secalinus.
No groove on one side. 20.

20. Achene seal brown, polished, ovoid. Ambrosia artemisiifolia.
Achene tan, cup shaped at apex. Cirsium arvense.

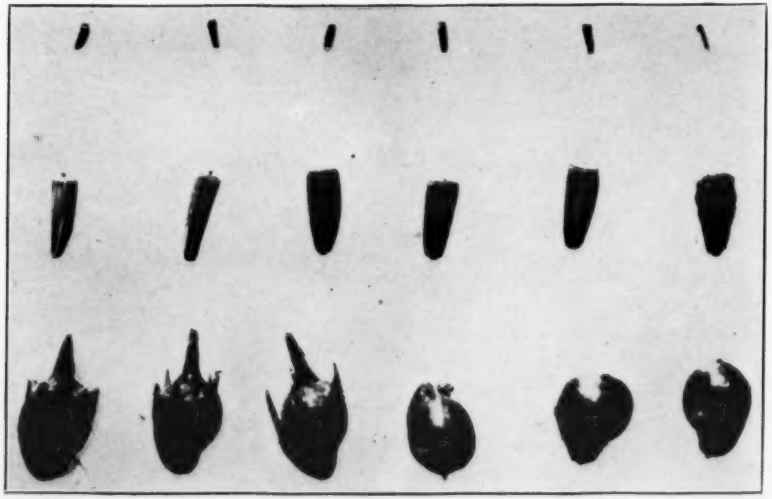
Descriptions

Gramineae. *Grass family*

Setaria glauca. *(Ixophorus glaucus.)* Yellow fox-tail. Pigeon grass. After rubbing, the spikelet consists of a grain or caryopsis and two firm coverings called respectively lemma and palea. This seed-like structure is straw colored, concave on one side and very convex on the other; prominent transverse striations mark the surface of the lemma and palea; apex slightly three toothed; 2.5 to 3 mm. long and 1.5 mm. in diameter. Common impurity in clover, millet, alfalfa and timothy. Plate I.

Setaria virdis. *(Ixophorus viridis.)* Green fox-tail. This seed-like structure, as in Setaria glauca, consists of a grain or caryopsis and two firm coverings. It is green, having the surface marked by faint transverse striations; 1.5 mm. to 2 mm. long and .8 mm. in diameter. Common in clovers, alfalfa, and millet. Plate I.

Digitaria sanguinalis. *(Syntherisma sanguinalis.)* Finger grass. Large crab grass. After severe rubbing, the spikelet consists of a grain or caryopsis and two firm coverings—lemma, which is on the convex side, and palea. It is straw col-



Row 1. Erigeron annus.

Row 2. Cichorium Intybus.

Row 3. Ambrosia artemisiifolia.

PLATE III.

ored to gray, bobbin like, surface marked by vertical lines; 2 to 2.5 mm. long. In grass, red clover and alfalfa. Plate VI.

BROMUS SECALINUS. Cheat, Chess. Grain or caryopsis, reddish brown, somewhat spindle shaped, vertical groove on one side to which is often attached a row of bristles; 6 to 7 mm. long. Impurity of wheat and red clover. Plate V.

POLYGONACEAE. *Buckwheat family.*

RUMEX CRISPUS. Curled dock. Yellow dock. Narrow-leaved dock. Achene brown, shiny, three sided, apex attenuate; 1.5 to 2 mm. long and 1.3 mm. in diameter half-way between base and apex. Common impurity in red clover, alfalfa and grass seed. Plate II.

RUMEX OBTUSIFOLIUS. Broad-leaved dock. Bitter dock. Achene dark brown, three sided, very attenuate at apex; 2 to 2.5 mm. long and 1 to 1.3 mm. in diameter half way between base and apex. In red clover and alfalfa. Plate II.

RUMEX ACETOSELLA. Field sorrel. Sheep sorrel. Redtop sorrel. Achene not easily freed from reddish brown calyx. Three sided, angles rounded, abruptly pointed at apex; 1 to 1.5 mm. long. In clover, alfalfa and grass seed. Plate II.

POLYGONUM CONVOLVULUS. Black bindweed. Wild buckwheat. Achene black, three sided, angles rounded, concave sides; 3 mm. long and 2 mm. in diameter half way between base and apex. Common in red clover, barley and oats. Plate II.

POLYGONUM PENNSYLVANICUM. Pennsylvania smart-weed, Pennsylvania persicaria. Achene jet black, lenticular, surface finely granular, short abrupt apex; 2.5 mm. short diameter and 3 mm. long diameter. Common impurity of red clover. Plate I.

CHENOPODIACEAE. *Goosefoot family*

CHENOPODIUM ALBUM. Smooth pigweed. Lamb's quarters. Pigweed. White goosefoot. The seed when deprived of its covering, which is the calyx and the wall of the utricle, appears black. If this covering is not removed, it appears gray. Somewhat lens-shaped, a groove extending nearly half way from edge to center; 1.5 to 1.8 mm. in diameter. Often in clover, alfalfa, and grass seed. Plate V.

SALSOLA KALI *(Salsola Tragus.)* Russian thistle. Seed conical, embryo coiled, gray; 2 mm. in diameter. In clover and alfalfa. Plate IV.

AMARANTHACEAE. *Amaranth family*

AMARANTHUS GRAECIZANS. Tumbleweed. Seed shiny black. highly polished, circular with notch at one edge; .7 to .9 mm. in diameter. In red clover and grass seed. Plate V.

AMARANTHUS RETROFLEZUS. Rough pigweed. Redroot. Seed similar to Amaranthus graecizans in color, ovate with notch at edge; 1 to 1.2 mm. long and .8 to .9 mm. in diameter at base end. In red clover and grass seed. Plate V.

CAROPHYLLACEAE. *Pink family*

STELLARIA MEDIA. *(Alsine media.)* Common chickweed. Seed brownish, three to six curved rows of tubercles, flattened; a groove extending about ⅓ distance to the center; 1 mm. in diameter. In red clover, alsik clover and alfalfa. Plate IV.

SILENE ANTIRRHINA. Sleepy catchfly. Seed lead colored, four to six rows of curved tubercles on each side; .5 mm. in diameter. In grass and red clover seed. Plate IV.

CRUCIFERAE. *Mustard family*

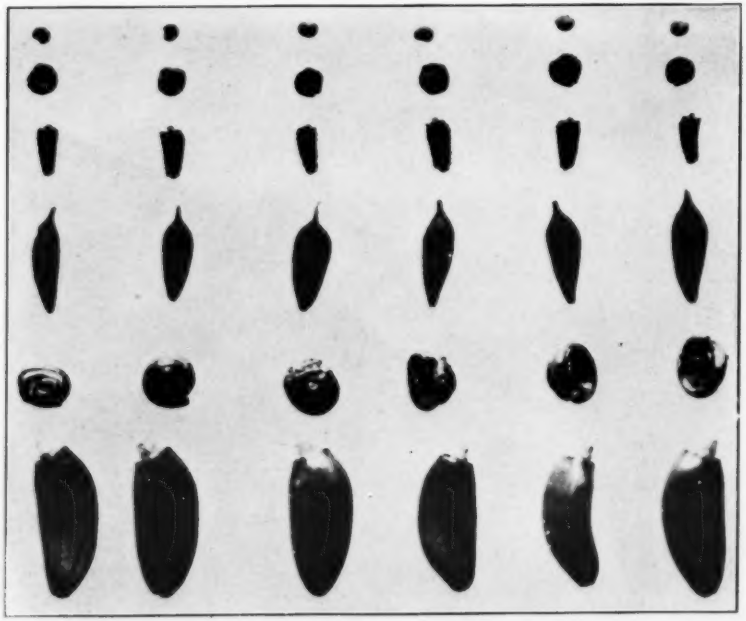
BRASSICA ARVENSIA. Chalock. Wild mustard. Seed black, spherical with surface finely reticulated; 1.2 mm. to 1.5 mm. in diameter. Common impurity of red clover, timothy and alfalfa. Plate VI.

BRASSICA NIGRA. Black mustard. Seed brownish, globose, the surface more coarsely reticulated than the surface of Brassica arvensis; 1.3 to 1.8 mm. in diameter. In red clover and timothy seed. Plate VI.

LEPIDIUM VIRGINICUM. Wild peppergrass. Tongue grass. Common peppergrass. Large peppergrass. Seed reddish to yellow, flat, surface granular, two-thirds ovate; 1 to 1.5 mm. in diameter. Common impurity of clover, alfalfa, and grass seed. Plate I.

CONVOLVULACEAE. *Convolvulus family*

CUSCUTA ARVENSIS. Field dodder. Seed yellowish brown, ovoid to spherical, ridge on one side, the other rounded; surface minutely pitted; .6 to 1 mm. in diameter. Common impurity of alfalfa and red clover seed. Plate V.



Row 1. Silene antirrhina.

Row 2. Stellaria media.

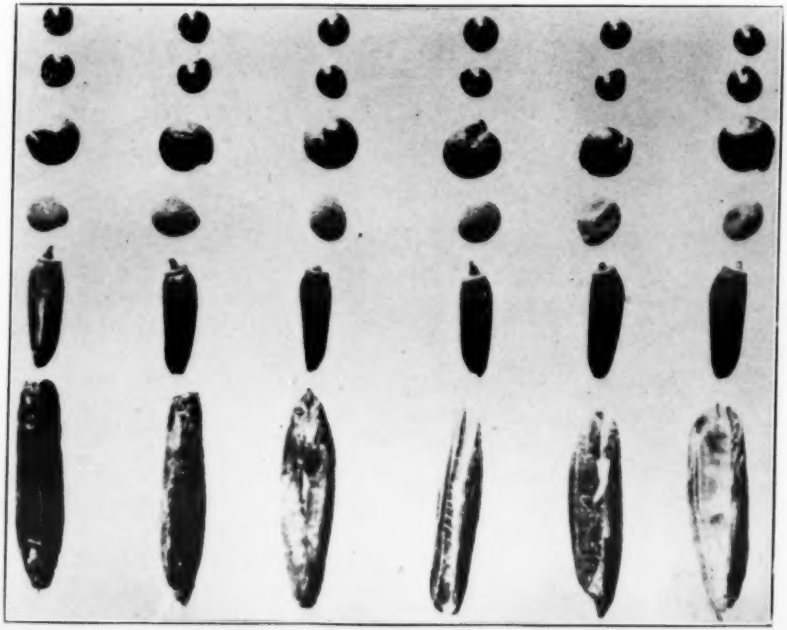
Row 3. Anthemis Cotula.

Row 4. Lactuca scariiola.

Row 5. Salsoli Kali.

Row 6. Cirsium lanceolatum.

PLATE IV.



Row 1. Amaranthus graecizans.

Row 2. Amaranthus retroflexus.

Row 3. Chenopodium album.

Row 4. Cuscuta arvensis.

Row 5. Cirsium arvense.

Row 6. Bromus secalinus.

PLATE V.

BORAGINACEAE. *Borage family*

LITHOSPERMUM ARVENSE. Wheat thief. Bastard alkanet. Corn Gromwell. Stoneseed. Redroot. Nutlet dull brown, apex pointed, base truncate having 2 white tubercles, keeled on inner side; 2.5 to 3 mm. long and 1.5 mm. wide half way between base and apex. Common impurity in wheat, rye, clover and alfalfa seed. Plate VI.

SOLANACEAE. *Nightshade family*

SOLANUM CAROLINENSE. Horse nettle. Bull nettle. Sand brier. Seed lemon yellow, slightly double convex, surface granular; 1.5 to 2 mm. in diameter. Impurity of clover and grass seed. Plate I.

PLANTAGINACEAE. *Plantain family*

PLANTGO RUGELII. Red-stem plantain. Rugel's plantain. Seeds brown to black, coarsely granular, angles acute, forms variable—oval, oblong, rhomboidal; 1 mm. in diameter at widest place and 2 to 2.5 mm. long. One of the most common weed seeds in clover, alfalfa and grass seed. Plate I.

PLANTAGO ARISTATA. Large bracted plantain. Western buckhorn. Seed brown, canoe shaped with convex side marked by a transverse groove; a white line bounding base of canoe inside, two pits appearing from concave side; 1.2 to 1.5 mm. in diameter and 2.5 to 3 mm. long. Common impurity of red clover and alsike clover. Plate II.

PLANTAGO LANCEOLATA. Buckhorn. Narrow leaved plantain. Rib grass. English plantain. Seed brown, canoe shaped with thick wall, a scar seen from middle of concave side; 1 mm. in diameter and 2mm. long. Common impurity of red clover, alfalfa, alsike clover and grass seed. Plate II.

COMPOSITAE. *Composite family*

ERIGERON ANNUM. Daisy fleshbane. Sweet scabious. Whiteweed. White-top. Achene brownish-white, slightly hairy with whorl of short bristles at apex; .3 mm. in diameter and 1 mm. long. Impurity of grass seed. Plate III.

AMBROSIA ARTEMISIIFOLSA. Common ragwed. Small ragweed. Hogwood. Roman wormwood. Wild tansy. Involucre grayish, top-shaped, armed with 6 to 10 short, acute spines; 3.5

to 4 mm. long. If there has been thrashing, the outer covering may have been removed, exposing the achene. It is seal brown, the surface polished, ovoid, a large tubercle at the base; 2.5 mm. long and 1.5 to 1.8 mm. in diameter. Common impurity of red clover, wheat, barley and grass seed. Plate III.

ANTHEMIS COTULA. Dog-fennel. Mayweed. Dillweed. Achene brownish, obovoid, the surface warty ribbed, a tubercle projecting from the apex; 1.3 to 1.5 mm. long. Common impurity of red clover, timothy, blue grass and alfalfa seed. Plate IV.

CIRSIUM LANCEOLATUM. *(Carduus lanceolatus.)* Common thistle. Bull thistle. Burr or spear thistle. Achene straw colored, slightly flattened, the surface marked by vertical stripes, a large tubercle in the center of a cup-like apex; 4 to 5 mm. long and 1 to 1.5 mm. in diameter. Common impurity in clover, alfalfa and grass seed. Plate IV.

CIRSIUM ARVENSE. *(Carduus arvensis.)* Canada thistle. Creeping thistle. Achene tan color, obovoid, to oblong, cup-shaped at apex with a small tubercle in the center of it; 3 to 3.5 mm. long and .7 to 1 mm. in diameter. Common impurity of clover, alfalfa and grass seed. Plate V.

LACTUCA SCARIOLA. Prickly lettuce. Compass plant. Achene brownish, obovate with many black-spotted vertical ridges, widest towards the tapering apex; 3 to 3.5 mm. long. In grass seed. Plate IV.

CICHORIUM INTYBUS. Chicory. Blue sailors. Wild succory. Bunk. Achene light brown, often curved, the apex truncate and crowned with two rows of scales; 2.5 to 3 mm. long and .8 to 1 mm. in diameter. Common impurity of red clover and alfalfa seed. Plate III.

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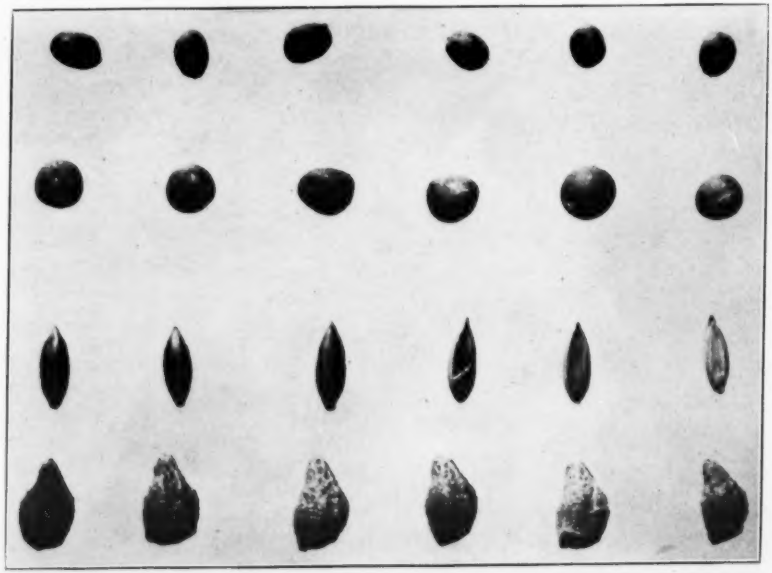

Row 1. Brassica nigra.

Row 2. Brassica Arvensis.

Row 3. Digitaria sanguinalis.

Row 4. Lithospermum arvense.

PLATE VI.

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Papers on Zoology

GEOGRAPHICAL VARIATION OF NOTEMIGONUS CRYSOLEUCAS—AN AMERICAN MINNOW

By Carl L. Hubbs

Museum of Zoology, University of Michigan

The golden shiner is one of the most distinctive and best known of all the American minnows. It is usually abundant in sluggish streams and weedy ponds from New Brunswick, Ontario and North Dakota southward to Florida and Texas. Under favorable conditions it reaches a length of about one foot, and a weight of about a pound and a half, but in small ponds it is more or less dwarfed, breeding at the age of one or two years. Thus in the San Diego River of California, which is reduced during the dry season to a chain of small disconnected pools, the golden shiner, although it has become abundant since its introduction, is so greatly dwarfed that the largest adults I was able to obtain are scarcely more than three inches long to the base of the caudal fin. Most of these fishes in the San Diego River become mature at the end of their first year, and do not acquire, or acquire only in part, the peculiarly deep body which is characteristic of the adult as usually found in its native waters[1]. I have also examined mature dwarfed examples from Texas, Iowa and Ohio, but these specimens, although small, have usually acquired the deep form of the larger adults. This dwarfing is one instance of the great adaptability of the golden shiner.

Excluding a doubtful form, *Notemigonus crysoleucas* is the only species in its genus. It has been recognized,[2] however that the species is divisible into two intergrading subspecies: *crysoleucas* proper, from the greater part of the wide range of the species, and *boscii*, from the South Atlantic States and Florida. The variations and inter-relationships of these two subspecies, in the different parts of their range, form the main theme of the present paper.

[1]In discussing *Semotilus bullaris*, Dr. Kendall has recently stated (Bull. Bur. Fish., 35, 1918, p. 511): "Small adult fish resemble young of the larger fish, being silvery and having a dark stripe along the side". Similar neotenic relations, as is well known, prevail in the Salmonidae.

[2]First by Jordan and Meek (Proc. U. S. Nat. Mus., 8, 1885, p. 15).

According to current descriptions, *boscii* differs from *crysoleucas* in the larger scales; in the brighter colors of the breeding male, ad in the greater length of the anal fin. The variation to which these characters are subject has been studied in some detail.

1. *The Size of the Scales*

In 56 counts of the number of transverse rows of scales in specimens of *boscii* from Florida and South Carolina, an extreme variation of from 42 to 53 rows was found, the mode of variation being about 46 rows. In 127 counts of the transverse scale rows of specimens from the given range of *crysoleucas* proper, the mode of variation is at 47 rows instead of 46; the extremes of variation (from 42 to 53 rows) as determined for *boscii,* were found to hold also as the usual extremes for typical *crysoleucas,* although two specimens showed a higher number (in one case 55, in the other 57, on one side only). These figures indicate that there is no wide geographical variation in the size of the scales of *Notemigonus crysoleucas.*

In both *crysolucas* and *boscii* the lateral line is frequently variously incomplete.

2. *The Colors of the Breeding Male*

In the southeastern form, *boscii,* the males in the spring are described as assuming bright colors, caused chiefly by the development of red color on the lower fins. In typical *crysoleucas,* however, the lower fins are usually marked with orange in the breeding fishes (of both sexes), and these fins are occasionally red.[3] o data is available on the intergradation of the two forms in respect to coloration.

[3]Dr. Tarleton Bean (Bull. Am. Mus. Nat. Hist., 9, 1897, p. 344) described as a race of *crysoleucas,* a fish from Central Park, New York City, characterized by the "permanent vermilion color" of the lower fins. Hk apparently was dealing however with examples of an introduced European species, *Scardinius erythrophthalmus.*

3. *The Number of Rays in the Anal Fin*

The longer anal fin of *boscii,* containing more rays than that of *crysoleucas* proper, is the most important of the characters which distinguish the two forms. Within the species, including the two subspecies, the variation in the number of branched rays in the anal fin is from 8 to 17, more than one hundred per cent. A variation of five rays, which is unusually wide when the number is so low, occurs normally in a single lot from a single locality. Thus, in a series from Saginaw Bay, Michigan, the rays vary from 8 to 12; from Dewey Lake, Michigan, 10 to 14; from the Huron River basin, Michigan; from Pikeville, Indiana, 9 to 13; from Lake Monroe, Florida, 13 to 17.

The most intersting aspect of this variation in the number of branched rays of the anal fin is not its wide extent, but rather the geographical distribution of its variants. This is indicated in the two following tables.

Tables showing the geographical variation in the number of branched rays of 465 specimens of Notemigonus crysoleucas. branched rays of 487 specimens of Notemigonus crysoleucas.

Branched annal rays	Localities (states)
8 9 10 11 12 13 14 15 16 17 1 7 42 203 119 23 2.....	North Dakota, Wisconsin, Michigan, Ontario, Nova Scotia, Iowa, Northern Missouri, Illinois, Indiana, Ohio.
.....2 12 17 7.....	Texas, Louisiana, Arkansas, Oklahoma, Southern Missouri, Virginia, Maryland, Delaware, Pennsylvania.
.....4 12 23 14 1	South Carolina, Georgia, Alabama, Florida.

Estimated modal numbers of branched anal rays	*Regions*
11	Red River of the North
11	North Dakota
11	Wisconsin (Lake Pepin)
11	Michigan
11	Northern Illinois
11	North central Ohio
11½	Iowa and northern Missouri
11½	About southern end of Lake Michigan
12	Indiana
12	Western Ohio
13	Southern Missouri
13	Texas
13	Arkansas
13	Maryland and Potomac River
13½	Southern Virginia
14	Alabama
14½	South Carolina
15	Florida

It thus appears that, as regards the number of anal rays, the most important distinctive feature, *crysoleucas* blends into *boscii*, the number of rays becoming gradually more numerous from the northwest to the southeast. How gradual this intergradation really is, can be emphasized by considering the conditions in Illinois and the adjacent states. In Indiana I find the number of anal rays to vary from 9 to 14, twelve occurring most frequently. In Michigan, in northern Illinois, and in the states to the west of Illinois, I find the variation to be from 8 to 13 instead of 9 to 14; the number 11, rather than 12 occurring most frequently. It seems rather surprising that the golden shiners of Indiana should present this slight racial difference when compared with others from the Illinois River basin, but the difference is in agreement with the more southern facies of the fauna just southeast of Lake Michigan. About the southern tip of Lake Michigan the modal number is between 11 and 12.

Among stream fishes, the distribution of species and variants is usually correlated, not with latitude or area, as in the case of terrestrial animals, but rather with the extent of the stream basins themselves: for the history of the streams and the history of the stream fishes are intimately connected. The case of the golden shiner forms one of the apparent exceptions to this general law, for in *Notemigonus* the distribution of the variants seems to be correlated with area and perhaps with temperature, rather than with the stream basins. A closely similar case appears to occur among the sun-fishes, and others will probably be demonstrated when our freshwater fishes are more extensively studied.

THE MOLLUSCA OF PIATT, CHAMPAIGN, AND VERMILION COUNTIES OF ILLINOIS

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This report on the mollusks of these three counties is based upon collections and observations made from the Autumn of 1907 to the Summer of 1911, supplemented by such additional data as given in Baker (1906). The late Mr. Charles A. Hart accompanied me on a great many of these excursions and took a lively interest in the study; to him particularly I wish to show my gratitude.

I am also greatly indebted to the following gentlemen: Dr. Charles C. Adams for valuable suggestions and interest in the survey; to Dr. Frank C. Baker for accurate determinations of my material and checking on my identifications; Dr. Victor Sterki for identifications of the Sphœriidœ and Ppidœ; Dr. Bryant Walker for determination of *Paravitrea significans;* my colleagues, Drs. J. Douglas Hood, Arthur G. Vestal, Robt. D. and Hugh Glasgow, H. E. Ewing and Frank Elmer Wood, for contributions of specimens; Drs. Wm. Healey Dall and Paul Bartsch for their kindness in going over the manuscript and bringing the nomenclature to date; and finally to the pioneer ecologist, Dr. Stephen Alfred Forbes, for the use of his library and for valuable suggestions.

Baker's catalog of the mollusks of Illinois (1906) lists one species from Piatt Co., twenty-three from Champaign Co., and four from Vermilion Co. The present paper lists fifty-two, seventy-eight and sixty-seven species respectively, a total of one hundred and sixteen species. The important fact to note is that the material on which this paper is based was collected at odd times, and nearly always when engaged in entomological work. An exception to this is the Brownfield Woods (also known as the Augerville Woods) near Urbana, where a special study was made of the ecology of forest inhabiting snails for a thesis. It is clear that this paper cannot be considered as even fairly

complete, for if an intensive survey is made, the number of species will probably be over two hundred.

Primarily as a stimulus to others, in the hopes that we may know more of the ecology of our mollusk-fauna, I prepared a map of Illinois on which I summarized our knowledge of this fauna to date. In the preparation of this map I followed the data given by Baker and that in this paper. There are only five counties with more than one hundred species reported from them, and what is most regretable, there are thirty-two counties of which we have no record at all. Almost one-third

of the entire State, representing some of our richest faunal regions, is still almost unknown so far as mollusks are concerned!

It is to be hoped, however, that none shall stop at mere collecting of specimens, but that notes shall be taken of the ecology of the species found,—that apparent maze of interrelations existing between individuals, species and the complex environment, which, combined, spell life and give to Nature true orientation and significance.

THE MOLLUSCA OF THE THREE COUNTIES

The following are the localities visited:

Piatt Co. (1 and 2) White Heath and Monticello; four trips to the Sangamon River and one trip to a small patch of woods near White Heath.

Champaign Co. (3) Urbana; five visits to Mr. C. A. Hart's back yard at 923 W. Green St., where several logs rested undisturbed for years. (4) Mount Hope Cemetery, south of Urbana, one trip. (5) Crystal Lake and cut-offs near Urbana, nine trips. (6) Salt Fork, Urbana, one trip to the historic "boneyard" branch, three to the main stream, and one to a sewer outlet. (7) Brownfield (Augerville) Woods, 3¼ miles Northeast of Urbana, about sixty trips. (8) the Cottonwood Woods, 4 miles Northeast of Urbana, near the Brownfield Woods, ten trips. (9) St. Joseph, Salt Fork and Spoon Creek, two trips. (10) Homer and Homer Park, one trip.

Vermilion Co. (11) Muncie, five trips to Stony Creek and to the woods bordering it, one trip to the Salt Fork. (12) Hillery, two trips to the Middle Fork and the woods bordering it, one trip to the woods north of Hillery. (13) Danville, one trip to woods northwest of town.

Peculiarities of the Fauna

The Sangamon River. It is a tributary of the Illinois River. During late Summer and Autumn it is very shallow at White Heath and Monticello. Due to the very high rises in Spring, which often overflow the river's flood-plain, great changes occur in the mollusk habitats. In addition to the changes in depth of water and current, the character of the bottom changes in

many places. What was gravel one day, is sand the next, or an ox-bow forms and the channel is changed over night. *Amblema undulata, Quadrula pustulosa, Fusconaia rubiginosa, F. coccinea, Tritogonia tuberculata* and *Eurynia fasciata* were the dominant clams. The less common species were: *Lampsilis ventricosa, L. anodontoides, Strophitus edentulus, Anodonta grandis, Anodontoides ferussacianus subcylindraceus, Lasmigona costata, L. complanata, Alasmidonta calceola* and *A. marginata.*

With the exception of *Eurynia fasciata,* the dominant clams are summer breeding forms, i. e., the sex products mature from fall to Spring, and the young are discharged during the Summer months. The others are the winter breeding species, the embryos of which mature in Spring and are set free in Autumn and the following Spring. The summer breeders find plenty of water when their young are discharged, also plenty of fish to which these young glochidia may become attached. Conditions appear, therefore, more favorable to the development of this type of clam. On the other hand, the Winter breeders find the river very shallow and with fewer fish when their young are released. This hypothesis seems valid as an explanation of the abundance of certain clams at this particular place.

At Havana, Illinois, the Illinois River is very broad and deep all year round. Fish are always plentiful. Therefore both the Summer and Winter breeders are in abundance. It would appear also that as the Spring rains swell the tributaries of the Illinois River, that fish from it will swim up these tributaries to spawn and bring with them the encysted glochidia, and that these are set free in these tributaries. As the late Summer and Winter conditions of the Sangamon River are not favorable to the development of these tiny clams, only a few survive. Whether or not these explanations are true, remains to be proven by more intensive studies.

Prof. F. E. Wood (1910, p. 558) gives the following count and list of clams that he found at White Heath, all of them in one heap and empty,—the results of a muskrat raid: 41 *Amblema undulata,* 4 *Quadrula pustulosa,* 1 *Fusconaia coccinea,* 7 *Lasmigona* sp., 3 *Tritogonia tuberculata,* 7 *Eurynia fasciata,*

1 *Lampsilis ventricosa*, 3 *Lasmigona complanata* and 1 *Anodonta grandis*. Such heaps were plentiful and show only too well how severe are the inroads made by *Fiber zibethicus* in the clam world, notwithstanding the fact that his chief food is vegetable matter. The muskrat takes the clams during Autumn, Winter and early Spring, when the corn and grain fields offer him no food.

Vermilion County. The Vermilion River, with its North and Middle Forks, rises in Ford and Iroquois Counties and drains into the Wabash River. The Middle Fork at Hillery contains much drifting sand. The depth of water varies in all these branches according to the season. Too few collections were made of the Unionidae to warrant making definite conclusions, however, it is evident that in several respects the fauna of this drainage system is quite different from that of the Sangamon. *Quadrula cylindrica* and *Obovaria circulars* collected here are typical of the Wabash Drainage.

The hillsides at Hillery are very favorable for *helices; Polygyra elevata, P. albolabris* and *P. thyroides* are the most abundant. Unfortunately man with his fire, destroyed an extensive area of this splendid *Polygyra habitat;* the calcined shells are strewn all over the place. Near the stream the lowland mesophytic plant association merges into a typical hydrophytic type with *Lymnæa humilis modicella, Segmentina armigera* and *Carychium exile* as the dominant mollusks.

At Muncie is an excellent sample of dry upland association and near to it, a well-drained mesophytic association; unfortunately, the mollusk fauna was very limited in both species and individuals. This place no longer represents natural and normal habitats, being badly distorted and changed by hogs, cattle, horses and man. The stream at the Big Four R. R. crossing is very rapid, its bed being chiefly rock. On one side are high bluffs; on the other side is a broad, level flood-plain which exhibits several terraces. Numerous cut-offs occur, usually dry in Summer and Autumn. The small fauna of these is chiefly composed of *Lymnæa humilis modicella, L. caperata, Physa gyrina, Aplexa hypnorum, Planorbis trivolvis* and *Segmentina armigera. Mancassellus macrurus, Branchippus* sp.,

Amphipods, Odonata larvæ, and a host of aquatic and semi-aquatic insect larvæ and adults, are in abundance. It is a melting point of terrestrial and aquatic conditions, and the aquatic forms must endure much dessication when the waters dry up in late Summer. Numerous birds come here to find food.

Champaign Co. This county is at the divide between the Sangamon, Vermilion and Embarass Rivers. Champaign and Urbana are almost the highest portions of the county. The woods are nearly all cleared and pastured, and the few that remain, even if undisturbed by axe or stock, are more or less abnormal due to the inroads of great numbers of field mice and shrews during Winter when the adjoining corn fields no longer suit them. This destruction of our forests, and as a consequence the development of corn and grain fields, means the destruction of our larger land snail habitats, and it is only a question of brief time, if not actually now, when these large Polygyras will no longer be collected by the hundreds. This fact should inspire students to survey those counties of Illinois from which we have few or no records, counties which are so situated that they are still rich in natural abodes, undisturbed by man.

The Brownfield and Cottonwood Woods are located 3¼ and, 4 miles respectively, to the Northeast of Urbana. Their area is about eighty acres each. Until 1910 the only intruders in the Brownfield Woods (also called Augerville Woods), were rabbit hunters, botanists and entomologists. Since then, church picnics were held there, and more or less of a habit, fires were built and the burning embers not always extinguished, hogs and chickens entered, and trees were cut down by the neighbors. The Brownfield Woods is in the main part well drained, is composed chiefly of a mesophytic plant association, with a small sample of wet lowland type near the intermittant creek which flows thru the woods. The fauna of this creek is very poorly developed.

The mollusca of these woods are quite well developed; the following species have been collected: *Polygyra elevata, P. zaleta, P. pennsylvanica, P. thyroides, P. hirsuta, Circinaria concava, Zonitoides arboreus, Z. mimusculus, Z. nitudus,*

Vitrea indentata, V. hammonis, Paravitrea significans, Euconulus chersinus, Agriolimax campestris, Philomycus carolinensis, Pyramidula alternata, P. solitaria, P. perspectiva, Helicodiscus parallelus, Sphyradium edentulum, Succinea avara, Strobilops labyrinthica, Gastrocopta contracta, G. tappaniana, G. holzineri, Vertigo tridentata and *Carychium exile,* a total of twenty-seven species.

The Salt Fork drainage feeds into the Vermilion. The "Boneyard" branch is its source. A few intermittant feeders are found as far north as Rantoul, near the Mackinaw region where also the Sangamon has its source. The first Unios to be found are *Carunculina parva* and *Anodontoides ferussacianus subcylindraceus,* and wherever ox-bows are formed, *Anodonta grandis* is almost certain to be found. But few Sphæriidæ were found, no doubt more exist if only a more careful search is made for them. In the ecologically annotated list of species data is given covering the habitats of the Ancylidæ, etc., found here. At Crystal Lake the littoral fauna is well developed,—mostly insect and snail, of the latter *Lymnæa humilis modicella, L. parva, Pomatiopsis lapidaria* and *Physa gyrina* being the dominant forms.

In 1910 the Salt Fork was dredged and as a result many faunal changes occurred. Numerous ox-bows were formed and at times these were literally alive with *Carunculina parva, Musculium transversum* and several species of *Sphærium,* and of course, large numbers of dragon fly larvae and nymphs. On one occasion a nymph of *Gomphus* sp. was collected with one of its legs caught between the valves of *Sphærium striatinum.* The dredged area is practically devoid of mollusks, though in time these will invade it. During the Winter, *Physa gyrina* and *Planorbis trivolvis* were frequently found crawling on the underside of ice.

At St. Joseph, prior to dredging, the stream was rather wide and had very muddy banks. *Amblema undulata* and *Carunculina glans* were the most numerous clams. The latter was only found here and particularly near the outlet of a slaughter house. *C. parva* was not found at this particular place, though elsewhere it was common. Many of the "Quadrulas" were found with their shells deformed by the hoofs of cattle.

ECOLOGICALLY ANNOTATED LIST OF SPECIES

CLASS PELECYPODA

Order Prionodesmacea

Family Unionidæ

GENUS LAMPSILIS Rafinesque, 1820

Subgenus Lampsilis s. s.

1. *L. multiradiata* (Lea)—Reported by Mr. Wm. A. Marsh from the "Big Vermilion River." It prefers muddy or sandy bottoms, with only a few feet of water.

2. *L. ventricosa* (Barnes)—Found in all three counties,—at White Heath, Monticello, Salt Fork, Muncie and Hillery. It is a very variable species in color, rays, degree of corpulency and thickness of the shell. It prefers muddy bottoms of the larger streams, and is frequently associated with *Eurynia fasciata* Raf. At Havana, Ill., on the Illinois River, it is a very common clam.

GENUS EURYNI Rafinesque, 1820

3. *E. anodontoides* (Lea)—Found only at Monticello, Piatt Co. It is a member of the deeper water fauna, either muddy or sandy bottoms, where it can burrow; often among rocks near shores. In the Winter it burrows into the mud. At Havana, Ill., it is one of the most abundant clams.

4. *E. ellipsiformis* (Conrad)—Reported by Mr. W. W. Calkins from the "Vermilion River." Its habitat is about the same as that of *L. multiradiata.*

5. *E. lienosa* (Conrad)—Reported by Mr. Wm. A. Marsh from the "Little Vermilion River."

6. *E. ligamentina* (Lamarck)—Found only once, at Muncie, Vermilion Co., on a muddy bottom.

7. *E. fasciata* (Rafinesque)—Found in all three counties,—White Heath, Monticello, St. Joseph, Muncie and Hillery. Very plentiful. It prefers the larger streams and thrives on any kind of a bottom. Those on sandy bottoms are thicker-shelled. The St. Joseph specimens are quite thin.

8. *E. subrostrata* (Say)—Abundant at St. Joseph, Champaign Co., in quiet, muddy water. Dr. Charles C. Adams also found it very plentiful in a small pond, partly dried up, at White Heath, Piatt Co.

GENUS CARUNCULINA Simpson (in Baker), 1898

9. *C. glans* (Lea)—Found only at St. Joseph, Champaign Co., about the outlet to a slaughter house. *C. parva* also occurs in this stream but not at this particular place.

10. *C. parva* (Barnes)—St. Joseph and Crystal Lake, Champaign Co.; Hillery, Vermilion Co. The female shells are greatly inflated. The species prefers a muddy bottom, burying itself to a depth of several inches; slow streams, and nearly always near their sources, are preferred. Quite abundant.

GENUS OBOVARIA Rafinesque, 1819

(Subgenus Obovaria s. s.)

11. *O. circulus* (Lea)—Hillery, Vermilion Co. It is a typical member of the Wabash River Drainage System, and is quite abundant. It prefers the deeper waters.

GENUS TRITOGONIA Agassiz, 1852

12. *T. tuberculata* (Barnes)—Sangamon River, at White Heath and Monticello; very abundant and of large size. It lives in water of all depths, preferring a sandy bottom. Musk rats do not eat this species frequently because the valves fit tightly, and because at the least signs of any intrusion, *tuberculata* closes its valves tightly and keeps them closed for a long period. Musk rats prefer other clams, such as are easier to open.

GENUS STROPHITUS Rafinesque, 1820

13. *S. edentulus* (Say)—White Heath and Monticello, Piatt Co., St. Joseph, Champaign Co. In the larger streams and bayous, on muddy bottoms, usually associated with *Anodonta grandis*.

GENUS ANODONTA Lamarck, 1799

14. *A. grandis* (Say)—At all stations in the three counties, —in lakes, bayous, and streams, preferring waters devoid of current. Muddy bottoms are preferred. Very often the entire

outside of the shell is found to be covered with the bryozoon *Plumatella polymorpha*. A hydrachnid mite, *Diplodontus* sp. frequently infests the mantal cavity. Dead valves are very often found with *Ancylus* attached to them.

15. *A. grandis* Say var. *gigantea* Lea—Mr. Wm. A. Marsh reports it from the "Big Vermilion River." No specimens were collected which could be referred to this or any of the other varieties.

16. *A. implicata* (Say)—Only at St. Joseph, Champaign Co. The only other Illinois record is that of Mr. Marsh from Lake Co. The very great variation within the species of *Anodonta*, even among individuals of the same species, makes it very difficult to make accurate determination from shell characters alone. Slight differences in the habitat (from muddy to gravelly or sandy situations) often produce marked varietal differences. The St. Joseph specimens were all dead, and the identification was made by Dr. Frank C. Baker.

GENUS ANODONTOIDES Simpson (in Baker), 1898

17. *A. ferussacianus* (Lea) var. *subcylindraceus* (Lea)—Found in all three counties (Monticello, St. Joseph, Crystal Lake and Muncie), in small streams or near the sources of the larger ones; the habitat is much the same as that of *Caruncu-lina parva* with which species it is usually associated. Fairly abundant.

GENUS ARCIDENS Simpson, 1900

18. *A. confragosus* (Say)—Found only at Monticello and White Heath. It is a typical Illinois River species, abundant at Havana. Like *Eurynia anodontoides* and a few others, it appears to slowly ascend the Sangamon River, but the shallow water inhibits its establishment in large numbers.

GENUS LASMIGONA Rafinesque, 1831
Subgenus Platynaias Walker, 1917

19. *L. compressa* Lea—Hillery, Vermilion Co. Usually buried several inches in mud in streams that are neither deep nor rapid. It is fairly common.

Subgenus Lasmigona s. s.

20. *L. costata* (Rafinesque)—White Heath and Monticello only. This also is a deep river species which ascends in small numbers such tributaries as the Sangamon. It prefers muddy bottoms, but at one station it was the only form among the rocks. Muskrats prefer this species to other clams. This may account for the non-abundance of *costata* in shallow waters.

Subgenus Pterosygna Rafinesque, 1831

21. *L. complanata* (Barnes)—White Heath and Monticello, Piatt Co., St. Joseph, Champaign Co. Its habitat is much the same as that of *L. costata* and the two are usually found together. *Amblema undulata* is also usually associated with them. A specimen of *complanata* was found which measured ten inches across. Young shells are plentiful, and in many instances are distorted by cow hoofs.

GENUS ALASMIDONTA Say, 1818

Subgenus Pressodonta Simpson, 1900

22. *A. calceola* (Lea)—White Heath and Monticello. Associated with *A. marginata,* on muddy bottoms in water only a few feet deep.

Subgenus Rugifera Simpson, 1900

23. *A. marginata* (Say)—White Heath, Monticello and Hillery. With the preceding species; not very abundant.

GENUS ELLIPTIO Rafinesque, 1819

Subgenus Elliptio s. s.

24. *E. gibbosus* (Barnes)—White Heath, Piatt Co., collected by Dr. Charles C. Adams; also at Hillery, Vermilion Co. It prefers flowing waters of a few feet in depth only, with muddy bottoms in which these clams usually remain buried.

GENUS UNIOMERUS Conrad, 1853

25. *U. tetralasmus* (Say)—Crystal Lake, Champaign Co. Found always buried deeply in mud of quiet waters.

GENUS PLEUROBEMA (Rafinesque, 1820) Agassiz

26. *P. clava* (Lamarck)—Hillery, Vermilion Co., Dr. J. D. Hood, collector. This is another of the typical members of the Wabash River drainage. It prefers deeper waters, usually muddy bottoms.

27. *P. coccinea* (Conrad)—Monticello, Piatt Co., and Hillery, Vermilion Co. Fairly abundant at Monticello, in soft mud and usually seeking the deeper waters.

GENUS FUSCONAIA Simpson, 1900

28. *F. rubiginosa* (Lea)—White Heath, Monticello, St. Joseph, Homer Park, Muncie and Hillery. Very abundant; prefers the deeper waters, any kind of bottom.

GENUS QUADRULA (Rafinesque, 1820) Agassiz

Section Quadrula s. s.

29. *Q. cylindrica* (Say)—Hillery, Vermilion Co., Dr. J. D. Hood, collector. Rare at this place; typical of Wabash River drainage.

Section Theliderma (Swainson, 1840) Simpson

30. *Q. metanevra* (Rafinesque)—Deep waters of the Middle Fork at Hillery, Vermilion Co. Rare.

31. *Q. pustulosa* (Lea)—White Heath and Monticello, Piatt Co. This is another of the abundant and typical species of the Illinois River at Havana; it prefers muddy bottoms, but is often found among rock and sand.

GENUS AMBLEMA Rafinesque, 1819

32. *A. undulata* (Barnes)—In all three counties; very abundant. In streams and rivers of all depths, usually with muddy bottoms. Young shells are often deformed by cow hoofs. None of the closely related species, *A. plicata* and *Megalonaias heros* were found, although at Havana, Illinois, they are quite abundant.

GENUS ROTUNDARIA (Rafinesque, 1820) Simpson

33. *R. granifera* (Lea)—Only one dead valve was found at Hillery, Vermilion Co. It is very typical. The species probably inhabits the deeper waters.

Order Teleodesmacea

Superfamily Cyrenacea

Family Sphæriidæ

GENUS SPHÆRIUM Scopoli, 1777

34. *S. occidentale* (Prime)—Muncie, Vermilion Co., in soft mud of ponds and bayous, or cut-offs; abundant wherever the

current is sluggish or wanting. Usually associated with *Musculium transversum*. This Sphærium was often found in places completely dried up in the Summer.

35. *S. sulcatum* (Lamarck)—In soft mud at Crystal Lake, near Urbana. Not abundant.

36. *S. solidulum* Prime—A form very close to this species, and probably referable to it, was collected in mud at Crystal Lake, near Urbana; rare.

37. *S. stamineum* Conrad—Monticello, Piatt Co., St. Joseph and Homer Park, Champaign Co. In small creeks, rivers and ponds, buried in mud or among the roofs of aquatic plants.

38. *S. striatinum* Lamarck—Very abundant at Crystal Lake, St. Joseph, and the Salt Fork, Champaign Co., and at Hillery, Vermilion Co. It lives in soft mud, or at times sandy situations, buried often to a depth of eight inches. Among roots of water plants, associated with *Musculium transversum* and *M. partumeium*.

GENUS MUSCULIUM Link, 1807

39. *M. partumeium* Say—Crystal Lake, Salt Fork and Urbana, Champaign Co. Not very abundant, associated with *transversum* in soft, muddy bottoms.

40. *M. transversum* Say—Very abundant in all three counties, perhaps the most abundant of all the Sphæriidæ. Gregarious, usually associated with *M. partumeium, S. striatinum, S. occidentale* and some species of *Pisidia*. It lives in soft mud in ponds and slowly moving streams, under and among stones, among roots of aquatic plants and similar situations. Individuals were found with from 20 to 30 young within the mantle cavity.

41. *M. truncatum* Linsley—Reported from Urbana by Dr. Frank C. Baker, the specimens being in the collections of the Ill. State Lab. Nat. Hist.

GENUS PISIDIUM Pfeiffer, 1821

42. *P. compressum* Prime—Crystal Lake and Salt Fork, Champaign Co., buried in soft mud or among the roots of aquatic plants. It was very abundant in small streams and lakes.

43. *P. noveboracense* Prime—Salt Fork and in a stream of the Embarras River drainage, Northwest of Champaign, Champaign Co., in waters of moderate current, buried in soft mud or sand.

44. *P. walkeri* Sterki—Salt Fork, Champaign Co., associated with *P. compressum*, among roots of plants.

CLASS GASTROPODA
SUBCLASS Anisopleura
Order Prosobranchiata
Superfamily Taenioglossa
Family Viviparidæ

GENUS CAMPELOMA Rafinesque

45. *C. rufum Haldeman*—Monticello, Piatt Co. Also reported by Mr. Wm. A. Marsh from the Vermilion River. It prefers muddy shores of streams usually not very rapid; burrows in the mud.

Family Valvatidæ

GENUS VALVATA Muller, 1774

46. *V. bicarinata normalis* Walker—St. Joseph, Champaign Co., on water lilies and on the bottom of slowly moving streams or ponded waters, often burrowing itself into the mud or vegetable debris. It withstands much dessication.

Family Amnicolidæ
Subfamily Amnicolinæ

GENUS AMNICOLA Gould and Haldeman, 1840
Subgenus Amnicola s. s.

47. *A. limosa* Say var. *parva* Lea—Crystal Lake, Urbana, and Champaign Co. at St. Joseph, in mud and among roots of water plants, usually in shallow water where there is but little current.

Subgenus Cincinnatia Pilsbry, 1891

48. *A. cincinnatiensis* Lea—Monticello, Piatt Co., Crystal Lake and Urbana, Champaign Co., Muncie, Vermilion Co. On the surface of muddy bottoms or buried in same; also on aquatic plants and about roots; usually near shore.

Subfamily Pomatiopsinæ

GENUS POMATIOPSIS Tryon, 1862

49. *P. lapidaria* Say—Crystal Lake, Champaign Co. Amphibious; among vegetation and debris at margins of ponds. It withstands much dessication and is very often to be found in temporary waters.

Family Pueuroceridæ

GENUS PLEUROCERA Rafinesque, 1818

50. *P. elevatum* Say var. *Lewisii* Lea—White Heath and Monticello, Piatt Co. It prefers sandy bottoms of large streams, or among rocks. At Havana, Illinois, this is a very common species. The Piatt Co. specimens are very typical, and the species is fairly abundant, associated with *Goniobasis livescens.*

GENUS GONIOBASIS Lea, 1862

51. *G. livescens* Menke—Monticello, Piatt Co., and Hillery, Vermilion Co., among water weeds, on muddy or sandy bottoms; common.

52. *G. pulchella* Anthony—"Big Vermilion River" according to Mr. W. W. Calkins, Mr. E. C. Faust in the Journal of Parasitology (Vol. iv, No. 3) gives as the host of *Cercaria aurita* Faust, *G. pulchella,* but he does not state who determined his material. He gives as his locality "Salt Fork of Sangamon River, Homer," which locality is somewhat dubius,—geographically speaking.

53. *G. semicarinata* Say—"Big Vermilion River" according to Mr. Wm. A. Marsh. This may prove to be a mistake for *G. costifera* Haldeman, which species it resembles considerably.

Subclass Euthyneura

Order Pulmonata

Suborder Basommatophora

Superfamily Limnophila

Family Physidæ

GENUS PHYSA Draparnaud, 1801

54. *P. ancillaria Say* var. *warreniana* Lea—Crystal Lake, Champaign Co., *after* the Salt Fork was dredged. Not common. It resembles *P. sayii* but is only one-half its size. The specimens are mature.

55. *P. gyrina* Say—In all ponds and streams visited, in all three counties,—a most prolific and active species, probably the commonest of all gastropods. It is found on stones, twigs, aquatic plants, in slow running water, stagnant pools, ponds, rapid streams, temporary pools, at times in damp places far from bodies of water. It endures dessication. In January, 1909, I found it crawling on the under side of ice at Crystal Lake.

56. *P. sayii* Tappan—Urbana, Champaign Co., Dr. Frank C. Baker det. The specimens are in the collections of the Ill. State Lab. Nat. Hist. Excepting for *warreniana,* I found no *Physa* which approached *sayii.*

GENUS APLEXA "Fleming" Sowerby, 1822

57. *A. hypnorum* Linnæus—Muncie, Vermilion Co., in slowly moving or pounded waters, usually on plants or debris, under leaves, or on the muddy bottoms. It endures much dessication.

Family Ancylidæ
Subfamily Ferrissiinæ Walker, 1917

GENUS FERRISSIA Walker, 1903
Subgenus Lævapex Walker, 1903

58. *F. kirklandi* Walker—Salt Fork, Crystal Lake, and Urbana, Champaign Co. Found in great abundance on stems and the under sides of leaves of water lilies. The water of the lake was ponded since the dredging of the Salt Fork; this limpet was not found prior to the ponding of the waters of this lake. *F. tardus* was the only form found prior to this, but after the dredging of the Salt Fork, *tardus* disappeared completely and was replaced by *kirklandi. Gundlachia meekiana,* present in the lake before its waters became ponded, also disappeared.

(Subgenus Ferrissia Walker, 1903)

59. *F. rivularis* Say—White Heath, Piatt Co., Salt Fork, Urbana, Champaign Co., on sticks and plants. At White Heath, Piatt Co., Salt Fork, Urbana, Champaign Co., on sticks and plants. At White Heath it was found in a small stream near the Sangamon River, attached to rocks where the current was the strongest. In the Salt Fork also, it sought places of swift current.

60. *F. shicki* Pilsbry—Salt Fork, Urbana, Champaign Co. In the collections of the Ill. State Lab. Nat. Hist. Special attention was paid to the Ancylidæ to rediscover *shimeki*, but none were located.

61. *F. tardus* Say—Sangamon River at White Heath, Piatt Co., on stones and empty *Anodonta* valves, usually among rich algal growth, preferring quiet, shallow water. It was found at Urbana, Crystal Lake, and in the Salt Fork. See remarks under *kirklandi*. Mr. Charles A. Hart collected it at Muncie, on rocks in Stony Creek.

GENUS GUNDLACHIA Pfeiffer, 1850

Subgenus Kincaidella Hannibal, 1912

62. *G. meekiana* Stimpson—Crystal Lake, Urbana, abundant on floating sticks; April. After the Salt Fork was dredged and the waters of Crystal Lake became ponded, this interesting limpet disappeared.

Family Lymnæidæ

Subfamily Lymnæinæ

GENUS LYMNÆA Lamarck, 1799

Subgenus Pseudogalba Baker, 1913

63. *L. humilis* Say var. *modicella* (Say)—White Heath, Piatt Co., Crystal Lake, Champaign Co., Muncie, Vermilion Co. Very abundant, on sticks and woods, on muddy bottoms, etc., stones, of slow moving streams or ponds. It prefers the marginal zone, often entirely out of the water on damp, or moist mud banks; sometimes quite distant from water. At the Brownfield Woods it was present in the intermittant stream, a stream which was usually dry. This Lymnaea endure much dessication. It is associated mostly with *L. parva* and *Physa gyrina*.

64. *L. obrussa* (Say)—Urbana, Salt Fork, Crystal Lake, Champaign Co. In ponded waters, among leaves; also in small streams with sluggish current, upon sticks, leaves, stones, etc. It also can endure considerable dessication.

65. *L. parva* (Lea)—Salt Fork, Crystal Lake, Champaign Co., associated with *L. humilis modicella* and of more or less the same general habits. Not very common.

(Subgenus Galba Shranck, 1803)

66. *L. caperata* (Say)—Urbana and Cottonwood Woods, Champaign Co., Muncie, Vermilion Co. Usually in temporary bodies of water, ponds, bayous and slowly moving streams, preferring the outer zone where it lies among the vegetation and debris associated with *Aplexa hypnorum, Physa gyrina* and *Sphaerium occidentale.* Endures much dessication.

67. *L. palustris* (Muller)—Urbana, Champaign Co., collections of the Ill. State Lab. Nat. Hist. Young specimens were collected by me in 1910 in a creek feeding into the Salt Fork near a slaughter house at St. Joseph. The surfaces of these were much malleated.

Subfamily Planorbinæ

GENUS PLANORBIS Muller, 1774

Subgenus Hipeutis Agassiz in Charpentier, 1837

68. *P. exacuous* Say—Crystal Lake, Urbana, Champaign Co. Similar in habits and habitat as *P. parvus,* associated with it. Sometimes it is found on lily pads.

(Subgenus Gyraulus Agassiz [in Charpentier,] 1837)

69. *P. deflectus* Say—Crystal Lake, Urbana, Champaign Co. On sticks, stones, and plants in quiet waters, usually in deeper water than that preferred by *parvus.*

70. *P. parvus* (Say)—Monticello, Piatt Co., Crystal Lake, Urbana, and Salt Fork, Champaign Co. On stems of submerged plants and on objects in the water. Often in tangled masses of *Spirogyra* and other algae. Very abundant, often associated with *P. exacuous.*

(Subgenus Helisoma Swainson, 1840)

(Section Pierosoma Dall, 1905)

71. *P. trivolvis* (Say)—White Heath and Monticello, Crystal Lake, Urbana, Salt Fork, St. Joseph, and Homer Park, Muncie, Hillery and Danville. Very abundant, crawling along muddy bottoms of streams, ponds, etc., on sticks, stones, aquatic plants, etc. Gregarious. Associated usually with *Physa* and *Lymnaea.*

GENUS SEGMENTINA Fleming, 1817

72. *S. armigera* Say—Monticello, Piatt Co., Cottonwood Woods, Crystal Lake and Urbana, Champaign Co., Muncie,

Vermilion Co. In small streams and ponded waters, in hoof prints of cattle, marshy areas, etc., on aquatic vegetation, debris of all sorts, crawling on muddy bottoms, etc. Endures much dessication. Associated usually with other Planorbinæ.

Superfamily Akteophila

Family Auriculidæ

GENUS CARYCHIUM Muller, 1774

73. *C. exile* H. C. Lea—White Heath, Piatt Co., Brownfield Woods, Champaign Co., Hillery, Vermilion Co. Almost amphibious; very abundant in wet places under logs and pieces of wood, in wet moss, and quite often in standing water under logs. At Hillery it is the dominant mollusk of the swampy lowlands. Gregarious; on one occasion over a hundred specimens were taken from a log two feet long and about a foot in diameter. Its movements are slow and erratic, the long shell seemingly too heavy for the animal; it is carried at an angle of about 55°. This species usually occurs alone, but at times the following snails are its companions: *Gastrocopta contracta* and *tappaniana, Agriolomax campestris, Vitrea hammonis* and *indentata,* and *Zonitoides arboreus.* Of these, the most common companion is *G. Contracta.* In very wet places it is associated with the smaller species of *Lymnaea.* No specimens of *C. exiguum* were found, although Baker ('02, p. 256) states the two species are almost always found together. Almost a thousand specimen of *Carychium* were examined.

Suborder Stylommatophora

Monotremata

Vasopulmonata

Orthurethra

Family Valloniidæ

GENUS VALLONIA Risso, 1826

74. *V. pulchella* Muller Monticello, Piatt Co., Urbana, Champaign Co., Danville, Vermilion Co. This is a species of the open prairie, and is plentiful under logs in open lots. I have never found it in the deep woods. No other species of *Vallonia* was found although a very careful search was made.

Family Pupidae

GENUS STROBILOPS Pilsbry, 1892

75. *S. affinis* Pilsbry—In back yard of Mr. C. A. Hart's home at 923 W. Green St., Urbana. Under logs that laid there undisturbed for many years. Not abundant with *Gastrocopta contracta.*

76. *S. labyrinthica* (Say)—Brownfield Woods only. Not common. It was found near the outer border of the woodland, in open spots as a rule. Under loose bark of logs, in half decayed wood, under logs, among dead leaves and in the sod at base of trees; usually associated with *Gastrocopta contracta, Zonitoides arboreus, Vitrea indentata* and *Euconulus chersinus.* Its movements are slow and deliberate. The shell is carried flat, occasionally wabbling from side to side.

GENUS PUPOIDES Pfeiffer, 1854

77. *P. marginatus* (Say)—Near the Cottonwood Woods, Champaign Co., and at Oakwood, Vermilion Co. This is a species of the open prairie, occurring under logs and railroad ties. It is seldom found in woods.

GENUS GASTROCOPTA Wollaston, 1878

78. *G. armifera* (Say)—Urbana and Mount Hope Cemetery, Champaign Co., Muncie, Vermilion Co. This species prefers the dry upland and open associations, living as a rule under logs, stones and other objects. Not found as yet in the deep forest.

79. *G. armifera* Say var. *affinis* Sterki—Monticello, Piatt Co., under a log in a wet lowland association. This subspecies appears to be adapted to more hygrophytic habitats than is *armifera* s. s.

80. *G. contracta* (Say)—At all localities in the three counties. This is the commonest member of the *Pupidae,* and next to *Zonitoides arboreus,* perhaps the commonest snail. It prefers the mesophytic forest, living there under a great variety of situations, and from this optimum, it runs into both upland and lowland types, being able to withstand more the hydrophytic than the mesophytic extremes. It commonly lives under bark and in the interstices of bark, under logs, etc. On one occasion fifteen specimens were collected from a square meter

of clear forest floor. It also lives in crumbly soil. It is associated with a host of other snails, particularly the following: *Helicodiscus parallelus, Zonitoides arboreus, Gastrocopta tappaniana, G. holzineri, Strobilops labyrinthica, Pyramidula perspectiva* and *alternata, Zonitoides nitidus, Z. minusculus, Vitrea indentata* and *hammonis, Paravitrea significans, Euconulus chersinus* and *Sphyradium edentulum.* All, or most of these, are species that inhabit the moist areas under logs, or under bark. In Mr. Hart's back yard, *contracta* was associated with *G. armifera, Vallonia pulchella, Euconulus trochiformis* and *Strobilops affinis.* The movements of *contracta* are slow and precise, the shell being carried erect, though appearing cumbersome for the animal.

81. *G. holzigeri* (Sterki)—Brownfield Woods, Champaign Co. Found only on one occasion, under a log, associated with *G. contracta and Helicodiscus parallelus.* It prefers exposed hillsides.

82. *G. pentodon* (Say)—Brownfield Woods, Champaign Co., Muncie, Vermilion Co., very rare.

83. *G. tappaniana* (C. B. Adams)—Monticello, Piatt Co., Brownfield Woods, and University Forest, Champaign Co., Hillery, Vermilion Co. This species is rare in the Brownfield Woods, occurring only in moist places, such as under logs, pieces of bark and dead leaves, stones, and rubbish of all sorts, or on twigs or at base of trees. At Hillery I found it under pieces of bark in the river bottoms, associated with *contracta* and *Carychium exile.* The shell is carried almost flat. The animal moves about very sluggishly.

GENUS VERITGO Muller, 1774

Subgenus Vertigo s. s.

84. *V. ovata* Say—Monticello, Piatt Co., low moist places, under leaves, stones, sticks, etc.

85. *V. tridentata* Wolf—Brownfield and Cottonwood Woods, rare. Under loose bark of fallen trees, associated with *Gastrocopta contracta* and *Sphyradium edentulum.* According to Binney, this is one of the more aquatic species. Shimek records it on rather exposed, rocky, moss-covered banks.

Subgenus Angustula Sterki

86. *V. milium* (Gould)—Monticello, Piatt Co. Under a log in a wet lowland association, with *Gastrocopta armifera* var. *affinis*. Rare.

Heterurethra
Superfamily Elasmognatha
Family Succineidæ

GENUS SUCCINEA Draparnaud, 1801

87. *S. avara* Say—Monticello, Piatt Co., Brownfield and Cottonwood Woods, Champaign Co. Not common. Usually found in a wet lowland association, attached to stones, leaves, stems and trunks of trees.

Sigmurethra
Superfamily Holopoda
Family Helicidae

GENUS POLYGYRA (Say, 1818) Pilsbry
Subgenus Triodopsis Rafinesque, 1819

88. *P. albolabris* (Say)—Hillery, Vermilion Co. It occurs plentifully among the leaves and under logs in the ravines of the moist woods. Usually associated with *fraudulenta, elevata* and *zaleta*. Forest fires almost wiped out this species and others of the genus from this area.

89. *P. clausa* (Say)—Danville, Vermilion Co., in moist woods, under a log; not common.

90. *P. elevata* (Say)—Brownfield Woods, Champaign Co., Muncie and Hillery, Vermilion Co. At Hillery, this species is very common on the wooded clay hillsides, and among the accumulations of leaves and debris in the ravines. Associated with *albolabris, thyroides, fraudulenta* and *zaleta*.

91. *P. fraudulenta* Pilsbry—Hillery, Vermilion Co., not very common. In the ravines, also in an outcrop of loess. Prefers a moist situation under fallen leaves or bark of logs. Usually associated with other of the larger gelices.

92. *P. mitchelliana* (Lea)—Hillery, Vermilion Co., among leaves on moist ground in the ravines. Rare.

93. *P. pennsylvanica* Green—White Heath, Piatt Co., Brownfield Woods, Champaign Co., Muncie and Hillery, Ver-

milion Co. The White Heath specimens are very dark, almost brick red in color. This species is usually found at the base of tree trunks and about logs, and among fallen leaves. A few times, in November, I noticed them in small cavities in the surface of the soil. It is usually associated with *Zonitoides arboreus, Pyramidula alternata* and *Polygyra thyroides. Circinaria concava* is often present as an intruder, as is evident from the number of empty shells of this *Polygyra.*

This *Polygyra* is very shy in nature, its movements slow, and as a rule very careful. The shell is carried back of the center of the animal and lies almost flat. The least disturbance causes the animal to retreat into its shell. Upon coming out again, it apparently uses much caution. Shrews eat this *Polygyra* quite often. In the burrow of one shrew, under a log, 93 empty shells of *pennsylvanica* were found. Of these, 42 (or 48%) had the spires broken by the shrew. It would appear that due to the extreme shyness of this snail, the shrew is obliged to break the shells in order to get at the animal. In this same place were 154 empty shells of *P. thyroides* of which only 23 or 16% had the spires broken. The habits of *thyroides* will be discussed in their proper place, suffice it to say here that this snail is bolder, and hence the shrew gets its choice meal with a minimum expenditure of effort.

94. *P. thyroides* (Say)—White Heath, Piatt Co., Brownfield and Cottonwood Woods, Champaign Co., Muncie and Hillery, Vermilion Co. About half of the specimens found were dentate. This species is our commonest of the larger helices, and is typical of the mesophytic woods. It endures conditions entering into the xerophytic and hydrophytic associations, but is able to get along much better in the wet than in the dry. Dryness causes it to aestivate. In the Cottonwood Woods it was very abundant. This woods is damper than the Brownfield. I found that in woods that were dry, though not exactly xerophytic, that there was a tendency among the *thyroides* to approach the subspecies *bucculenta.* While typically a ground species, *thyroides* has been found to ascend tress, having been found as much as ten feet from the ground. In this respect it resembles *Pyramidula alternata.*

In habits this species is very bold, and even when handled quite roughly, it does not withdraw into its shell. A small percentage, however, seem to be more cautious. This snail is a voracious feeder; its excrement is dark in color, often olive green, its form long and slender, spirally coiled. During Spring i. e., as they emerge from hibernation, the "basking" habit is well marked. The common short-tailed shrew, *Blarina brevicauda* Say, preys largely upon this snail. During Winter the shrews leave the barren corn fields and burrow into the woods. Here their burrows open under logs; the Polygras hibernate under logs, often in burrows of shrews. In fact it would appear as if *Blarina* prepares a suitable retreat for these snails in order that later, when snow covers the ground, its feast may be a certainty. In the notes under *pennsylvanica* reference was made to 154 empty shells of *thyroides* in a shrew's nest, and that of these, only 23 had the spires broken. The reason for this is that this snail is not timid and hence the shrew does not have to break the shell to get at the animal. The few broken shells probably indicate individuals that were somewhat cautious, or, due to considerable handling by the shrew, some of these snails retreated into their shells.

Shull ('07, P. 495) has shown that shrews move the snails near the ground surface as the temperature falls, and move them further into the burrows when the temperature rises. Dead shells were never transported. The basis for distinguishing between live and dead snails must be odor. Another serious enemy of *thyroides* is *Circinaria concava*.

95. *P. zaleta* (Binney)—Brownfield Woods, Champaign Co. (one young shell), Hillery, Vermilion Co. At the last place this species has its optimum habitat requirements, living in the damp, wooded ravine slopes, among dead leaves, twigs, debris, and in the loose crumbly earth and humus. It wants shade. Its companions are usually *albolabris elevata,* and *fraudulenta*. It is not a timid species.

(Subgenus Stenotrema Rafinesque, 1819)

96. *P. fraterna* (Say)—Hillery, Vermilion Co., in shaded, moist situations, under bark, leaves and logs. Usually with *thyroides*.

97. *P. hirsuta* (Say)—White Heath, Piatt Co., Brownfield and Cottonwood Woods, Urbana, Champaign Co., Muncie and Hillery, Vermilion Co. A rather common species, living in damp situations, such as under debris or bark of fallen logs, or under loose bark of standing dead trees. Adults from the Brownfield Woods vary greatly in size. The following snails are associated with it: *Gastrocopta contracta, Zonitoides arboreus, Vitrea indentata, V. hammonis, Polygyra thyroides, Pyramidula alternata* and *P. perspectiva.* The animal is very active. The young are more gregarious than the adults. I found this snail frequently among the gills of fleshy fungi, and among mycelium.

98. *P. monodon* (Rackett)—Muncie and Hillery, Vermilion Co. Its habitat is similar to that of *hirsuta,* excepting that it prefers drier situations. Usually it is found under stones. In one instance I found it in the open prairie, under a boulder. It associated with *Vitrea hammonis, Zonitoides arboreus* and *Pyramidula perspectiva.* The open prairie form is smaller than those from damp ravines.

Superfamily Agnathomorpha
Family Circinariidæ

GENUS CIRCINARIA (Beck, 1837) Pilsbry

99. *C. concava* (Say)—White Heath, Monticello, Brownfield Woods, Cottonwood Woods, St. Joseph, Homer Park, Muncie, Hillery and Danville. A fairly common species, found in almost all kinds of situations. At times it was found under four to eight inches of soil. It probably is also subterranean in habits. I have found it at night crawling boldly over logs in search of prey. It seems to prefer cool, damp woods, and at Hillery was rather abundant under debris on the banks of the Middle Fork of the Vermilion River. The species is more or less solitary in habits, though at times two and three may be found together; usually one or two of these disappear mysteriously. Ordinarilly *concava* is timid, but when in quest of food it knows neither fear nor delay, and its appetite is always voracious. The lair of *Circinaria* is decorated with the empty shells of its victims, in the main part species among which it had associated. These usually are our several species of *Polygyra, Vitrea ndentata, i Paravitrea significans, vonitoides*

arboreus and *Philimycus carolinensis*. It seems to have respect for the slimy mucus of *Philomycus*, but the stiff hairs on the shell of *Polygyra hirsuta* do not seem to worry it. It is nocturnal in habits.

Superfamily Aulacopoda
Family Zonitidæ
Subfamily Zonitidæ

GENUS VITREA Fitzinger, 1853

100. *V. hammonis* Strom—Monticello and White Heath, Piatt Co., Brownfield and Cottonwood Woods, Urbana, St. Joseph, Champaign Co., Muncie and Hillery, Vermilion Co. This species prefers a moist situation. It is gregarious, occurring in great numbers in crevices of the bark of decaying trees, logs and in debris. It is usually associated with *Euconulus trochiformis, Gastrocopta contracta, Zonitoides nitidus* and *Carychium exile.*

101. *V. indentata* (Say)—Monticello and White Heath, Piatt Co., Brownfield and Cottonwood, Urbana, St. Joseph and Homer, Champaign Co., Muncie and Hillery, Vermilion Co. Very abundant, gregarious, almost as abundant as *Z. arboreus*, occurring in almost as many diverse habitats. It was collected in the interior of very soft and wet logs, in small cavities in the pileus of a fleshy fungus *(Russula emetica* Fr.*)* in the interstices of bark, under logs, in crumbly soil under logs, in leaf mould, under loose bark of standing dead trees, in moss, under fallen twigs, under stones, in both high and low places, at times in situations that were quite dry. It was found almost always with *Z. arboreus* and *nitidus*, but frequently with the following species also: *Polygyra hirsuta, thyroides, monodon, fraterna,* and *fraudulenta, Helicodiscus parallelus, Pyramidula alternata, P. perspectiva, Vitrea hammonis, Paravitrea significans, Euconulus chersinus, Philomycus carolinensis, Strobilops labyrinthica, Gastrocopta contracta* and *Agriolimax campestris.*

In bringing to the laboratory Pupidæ, Zonitidæ and other of the smaller snails, it was quite an easy matter to separate *indentata.* All that was necessary was to slightly moisten the entire mass and then just pick up the snails that were crawling away. These were *indentata,*—it is not a shy species, in fact is perhaps our boldest and most active one. It carries its shell

at an angle of 45° but the rapid movements of the animal in crawling causes the shell to wabble from side to side. It is a voracious feeder. The eggs are tiny, 1.2 mm. by 0.99 mm. They are laid during April, and the young hatch in 21 days.

GENUS PARAVITREA Pilsbry, 1898

102. *P. significans* (Bland)—Brownfield and Cottonwood Woods, Champaign Co. Not common. This is the first record of this species in Illinois, and its range is thus extended about three hundred miles northward. Dr. Bryant Walker made the identification. Fourteen specimens were collected in three years, of these nine came from the Brownfield Woods. It occurs under logs, large limbs, etc., usually in the crumbly soil. In fact nearly all my material came from such soil. Moist, cool situations are preferred, and in the Brownfield Woods it was found only in the deepest ravines, and on the north slopes of these. In the Cottonwood Woods it was taken in the lowest portions, where the moisture was greatest. It appears to be subterranean in habits. It was collected with *V. indentata, Z. arboreus, Circinaria concava* (which feeds on it) and *Pyramidula alternata.* It is a very shy species. Its movements are slow and careful. The shell is carried at an angle of about 30° from the horizontal.

GENUS EUCONULUS Kobelt

103. *E. chersinus* (Say)—Brownfield Woods, Champaign Co. Not common. Under damp logs, in the interstices of bark, on fallen leaves, twigs, etc., and once under stones. It does not seem to prefer the very moist situations, and is usually associated with *Gastrocopta contracta, Paravitrea significans, Strobilops labyrinthica, Vitrea indentata, Zonitoides arboreus, Pyramidula alternata, Helicodiscus parallelus* and *Sphyradium edentulum.* The animal is very shy.

104. *E. trochiformis* (Montfort)—In Mr. Hart's back yard, Urbana, under a log; not very common.

Subfamily Ariophantinae

GENUS ZONITOIDES Lehman, 1862

105. *Z. arboreus* (Say)—White Heath, Monticello, Brownfield and Cottonwood Woods, Urbana, St. Joseph, Homer, Homer Park, Muncie, Oakwood, Hillery and Danville; almost

everywhere and in all sorts of situations; perhaps the commonest snail. It prefers damp places, especially under boards, logs, interstices of bark, fallen twigs, under stones, in leaf mould, and in crumbly soil. In Winter individuals are found all huddled together in deep crevices and in the burrows of insects. This species is associated with nearly all the mollusks found in the Augerville Woods, including those of the hygrophytic plant association.

Gregarious, very active, very voracious. The shell is carried at an angle of 45°, the head and neck stretched out far. The eye peduncles are always thrust out nervously, as if in search of danger. It is relatively easy to separate *arboreus* from *nitidus* and *hammonis* by the manner in which the shell is carried. In addition to this, the animal of *nitidus* is decidedly blacker. In *hammonis* the last whorl is much wider than in the other species.

106. *Z. minusculus* (Binney)—Monticello, Piatt Co., Brownfield and Cottonwood Woods, Urbana, Champaign Co., Muncie, Vermilion Co. Not common. Found in the woods among decayed logs, in humus and old leaves, under bark, etc. It prefers damp and cool habitats, but at times is to be found in moist prairie situations, under boulders. This species is probably subterranean in habits.

107. *Z. nitidus* (Muller)—Monticello, Piatt Co., Brownfield and Cottonwood Woods, Urbana, Champaign Co., Muncie and Hillery, Vermilion Co. This species is commonly gregarious under logs and loose bark. It prefers damp situations and so far has been found in this region only along the shaded ravines. It often congregates in the interstices of the bark. Associated with *arboreus, indentata, hammonis, Agriolimax campestris* and *Gastrocopta contracta.*

GENUS GASTRODONTA Albers, 1850

108. *G. intertexta* (Binney)—Reported by Mr. Wm. A. Marsh from Vermilion Co.

109. *G. ligera* (Say)—Reported by Mr. Wm. A. Marsh from Vermilion Co.

Family Limacidæ

GENUS AGRIOLIMAX Morch, 1868

110. *A. campestris* (Binney)—White Heath, Monticello, Brownfield and Cottonwood Woods, Urbana, St. Joseph, Homer, Homer Park, Muncie, Oakwood, Hillery and Danville. Another of our very abundant mollusks. It is found everywhere, in forest and open, on streets and walks, under debris of all kinds, under logs, bark, stones, leaves, etc., preferring cool, moist habitats as a rule, and associating with nearly all the terrestrial molluks, in particular with the Zonitidæ. In hydrophytic associations it is found with Lymnæidæ and Physidæ, sometimes in places that are extremely wet.

The average duration of the egg stage, as determined in the laboratory, was 13 days 7 hours. The eggs are spherical, 1.5 mm. to 2-5 mm. in diameter. Sometimes unusually large and elliptical eggs occur among them. The young slugs measure 3 mm. upon hatching.

Family Philomycidæ

GENUS PHILOMYCUS (Rafinesque, 1820) Ferussac

111. *P. carolinensis* (Bosc)—White Heath, Piatt Co., Brownfield Woods, Cottonwood Woods, Urbana, St. Joseph, Homer, Homer Park, Champaign Co., Muncie, Oakwood, Hillery and Danville, Vermilion Co. This is the commonest slug occurring under bark. It frequents "starting" bark of fallen or standing dead trees, sometimes in the interior of decayed trunks. With *Pyramidula alternata* it is the first invader under bark, thus favoring rapid disintegration of the wood. This slug is more or less solitary, but under the bark of a large log as many as a dozen specimens will be found scattered about.

The eggs resemble drops of whitish gelantine with their centers much whiter. They measure 4 mm. by 3.2 mm. When deposited they are practically spherical, but within a few hours they change to elliptical. The egg stage is approximately seventeen days.

This slug has frequently been found completely covered with the excrement of the larvæ of *Scoleocampa liburna*, a lepidopter that riddles dead, soft wood. In such cases the bark still covers the log, although it is completely loosened. This slug lives among certain ants *(Camponotus heruculaneus* L.*)*,

among salamanders *(Plethodon erythronotus)*, coleopterous larvæ (especially of *Pyrochoa flabellata*), diplopods, chilopods, etc. The ease and thoroughness with which this slug covers itself with thick mucus is, no doubt, a very successful protection against being devoured by other animals. Even *Circinaria* respects this slime.

Family Endodontidæ
Subfamily Endodontinæ

GENUS PYRAMIDULA Fitzinger, 1833
Subgenus Patula Held, 1837

112. *P. alternata* Say—At all localities in all three counties. Gregarious; fairly abundant. It seeks moist habitats, usually under starting bark, where, with the preceding species, it is the first invader. Under stones, leaves, debris, in humus, etc. It associates usually with Zonitidæ and Pupidæ. Considerable variation in the height of the spire was noted.

Specimens collected in very humid regions died if placed in cages that were not kept moist, but specimens collected in dry habitats, did well in the laboratory. If the cages were kept moist, these individuals also did well. This species is inclined to be quite bold, but when it must retreat into the coils of its shell, it secretes an abundance of red, frothy mucus which completely fills the aperture. This has saved many an individual from the carnivorous snail, but the short-tailed shrew, *Blarina brevicauda*, simply breaks the top of the spire and thus reaches its victim. On rainy days *P. alternata* climbs to a height of ten feet or more. Its eggs are white, opaque, agglutinated and almost spherical. They measure on the average 2.25 mm. in diameter, and the entire egg stage lasts about thirty days.

113. *P. solitaria* Say—Brownfield Woods, Champaign Co., and Muncie, Hillery, Vermilion Co. Only one specimen was found in the Brownfield Woods; it was juvenile, and was found buried in six inches of soil. At Muncie, six specimens were found in four inches of soil, under a log. Dead individuals were quite plentiful at Hillery. This species associates, as a rule, with *alternata*.

Subgenus Gonyodiscus Fitzinger, 1833

114. *P. perspectiva* Say—Brownfield and Cottonwood Wood, Champaign Co., Hillery and Oakwood, Vermilion Co. In the

Brownfield and Cottonwood Woods the species was abundant, usually two individuals found together. This is probably the northernmost range of this species; it is very abundant in Tennessee and Alabama. It seems to prefer a much drier habitat than the other Pyramidulas. It was also found under bark of standing trees. On one occasion it was collected under a boulder in the glacial drift near Hillery. At this same town, a dozen specimens were found under the bark of a single log. It associates with other Pyramidulas, and with the Polygyrinæ and Zonitidæ.

GENUS HELICODISCUS Morse, 1864

115. *H. parallelus* Say—At all localities in the three counties. It is plentiful in places, usually found in the crevices of the bark, under logs, in loose, crumbly soil, etc., preferring cool situations either moist or wet. It is very rare in the dry, open areas. It associates with the majority of the smaller forms. It appears to be subterranean in habits. The animal is very shy, its movements very slow. The shell is carried almost flat. In eating it nibbles at the surface of leaves, resembling in this respect the work of certain leaf skeletonizers of the insect realm.

Subfamily Punctinæ

GENUS SPHYRADIUM Charpentier

116. *S. edentulum* Draparnaud—Brownfield Woods, rare; only three specimens were found in three and one-half years. These were under logs of moderate size, and in the interstices of bark, associated with *Gastrocopta contracta*.

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SOME BIRD CHARACTERISTICS

W. S. STRODE, LEWISTON, ILL.

THE SHRIKE

This bird is variously known as the Butcher Bird, English Jay, Mouse Hawk, Winter Butcher and Summer Butcher.

It is one of the strangest of all our birds. Naturalists were long undecided where to place it, whether as an accipitrine or a Pica. That is, was he a hawk or a crow? He had the characteristics of both and lacked some of the essential features of both. For instance, he had all the courage, the fierceness and boldness of the hawks, but he had the feet of the magpie and the jay.

The upper mandible was notched and hooked like the hawks, but he had no grasping talons. He was a blood-thirsty killer like the hawks, but like the crows, jays and magpies, who secrete their food, he impales his prey on a thorn, barbed-wire fence, or hangs it by the head in a crotch or fork of a tree.

Then again he looks much like the southern mockingbird, builds a nest like one and in the same localities. Also he is an imitator; uses the notes of other birds as the mockingbird does, but does this to lure birds to his vicinity, that he may catch and kill them. So where did he belong?

Some ornithologists of the old world still insists that as he is a bird of prey, he should be classed with the raptores or hawks and owls. Then there was another trouble, he also looked much like the kingbirds and other flycatchers and like the king-

bird he would fight bravely and put to flight the biggest eagle, hawk or crow that came within his territory or menaced his baby birds that he was conducting about the fences and hedges, and so the merry war went on.

Finally it was decided that he did not properly belong any of these families and it was decided to give him a place to himself, the Larridae and a cousinship to the Vireos and Waxwings and there he will stay.

There are seven species of this bird in North America, over 100 in the world, two only to be found in Illinois and central states; these are the Winter or Northern Shrike and the Summer or Migrant Shrike.

These two species look very much alike except that the winter one is a little larger and with less black on back and wings. They are about as large as the Robin Redbreast. They are never very numerous, but in a winter drive of eight or ten miles, I often see one perched on a telephone wire facing the north and apparently oblivious of the coldest weather.

They sometimes come into the towns in pursuit of the House-sparrow, which, when they capture, they scalp, tear the skull open, feed on the brains and then hang the body up on a thorn or by the head in the forks of a limb.

If their killing propensities were confined to this sparrow alone, we might wish their shadows would never grow less. It has been thought the impaling process of birds, mice, grasshoppers, etc., is done for the purpose of afterwards coming back for another feast, but repeated observations have never shown them doing this. It is a cruel, strange trait that is inexplainable.

The shrike is an early nester, often in early March. The winter variety leaves early for the far north, and its place is taken by the summer species which nests with us. No attempt is made for concealment. A lone osage, orange or crab-apple tree by the side of the road where every passerby can see it, is a favorite location.

The nest on the outside is a rough looking affair, composed of many sticks and thorns, but lined with fine grasses and the

softiest downiest feathers that can be found. Eggs almost invariably six, grayish white and spotted with various shades of brown.

Later in the season, when the young have left the nest, it is a most interesting sight to see the parent birds with the six little chuckle-headed young ones lined up on a barbed-wire fence teaching them to catch grasshoppers. They are quite fearless when nesting, and I have had my hand severly pinched by the mother bird for daring to put it in her nest.

One winter time while driving along the road over in the Spoon-river country, a young farmer who was getting out his shock corn, called to me to "come over and see this mouse-hawk catch mice." I needed no second invitation, and going over watched the proceedings. The farmer would tear down a shock and a mouse would scamper from it across the snow to take refuge in another shock. The shrike that was perched in the top of a small tree, a full hundred yards away, would come as straight as a bullet, catch the mouse, beat it on the hard snow, toss it up in the air, catch it in a new place and hammer it some more, and then fly away with it across the river which was near by.

In a few minutes it would be back again, ready to repeat the performance. After seeing it kill two or three mice, I determined to take a hand, and when the next mouse raced across the snow, I gave chase to it, but the shrike was right on hand and not to be daunted by my presence. It was nip and tuck between the two of us, which would get the mouse but tuck won, flying right between my feet, catching up the rodent and after the pounding process, flew with it across the river where it had carried the others.

I now resolved as the stream was well frozen over, to cross and see what was being done with all these mice. A little way back from the bank, in the thick woods, I found a honey-locust tree with more than a dozen mice impaled on its sharp thorns. All seemed to be intact and the thorn in nearly all seemed to be through the throat.

It will sometimes make a dash at a caged bird hung in a window and lose its life.

A bold, fearless, cruel, rapacious bird, but on account of the great number of mice, grasshoppers, beetles, etc., which it destroys, believed to do much more good than harm and should not be wantonly destroyed.

THE PROTHONOTARY WARBLER.

This beautiful little bird is often called the Golden Swamp Warbler. Its mission seems to be to add a bit of cheer and color to the dark swamps and desolate places of the rivers and lakes. It is a deep orange-yellow except the wings and tail, which are a slaty blue. The female is not so intensely colored. The notes are a clear ringing tweet, weet, weet, out of all proportion to the size of the bird.

They will not be found in the parks or towns or wooded hills. They frequent no localities except rivers and lakes and swamps of willows and buttonwoods and borders of pools, only rarely do they nest over the water of a running stream. They associate with the tree swallows, grackles and red-wing blackbirds nesting in the same localities. Sometimes a grackle or a Jennie Wren will be found in the same tree, the Grackles occupying an open cavity higher up, while the warbler will choose one down nearer the water.

The male is extremely jealous of intrusion by others of his own tribe, upon his immediate premises he will scrap valorously if one of them comes near his chosen domicile, though he does not seem to object to the presence of other birds.

The Thompson Lake country on the Illinois river is headquarters for these strange warblers, strange because they stand almost alone in their habit of nesting in the holes of old stumps, snags and dead trees, almost always just a few feet above the water which sometimes rises and destroys their nests. They are queer too, because of the material used in constructing their nests, which, when it can be obtained is made almost exclusively from green moss that grows around the base of willow trees standing in the water or mud. If a high stage of water covers up this material, they will use instead, fine blades of grasses. However when the moss can be found, nothing else is used.

The cavity selected is most times one made by the downy woodpecker or chickadee, but sometimes cavities in live trees are used, mortices and knot holes in bridge piling and railroad trestles are used. The highest nest I have ever observed in many years observation, was one about twelve feet up in a little pecan tree, but rarely are they over six feet above water. The hole selected in the tree is packed full of the moss to within five or six inches of the opening, and then a cup-like depression is hollowed out to hold the eggs. The usual set of eggs is six, though sometimes only five. In my time I have seen three nests containing seven eggs.

The eggs are the most beautiful of all the bird families, almost round, smooth and glassy, creamy white, thickly spotted all over with reddish brown spots. They are hardly colony nesters as are the red-winged blackbirds and some others, but are restricted in their habitat and around Thompson, Mud-Grass, and the other lakes of this region, a pair will be found nesting every hundred yards or so if suitable conditions can be found.

On account of their frequenting old willows, dead snags, thunder-brush, etc., they are peculiarly the prey of the bird loving snakes, such as the Bull, King, Black Racer and Ring snakes, all of whom love a dinner of bird eggs or young birds.

The writer has often while pushing his boat around under the low growing willows and old snags and rapping on their hollow trunks had these reptiles come rushing out of a hole, fall into the boat and go scampering over feet and legs into the water. An investigation would usually result in finding a Prothonotaries nest with contents destroyed except sometimes a lone egg or young bird. Occasionally they do not vacate so readily, especially the bull snake, who will hang stubbornly to his possession and fight to the last, or till the stub is torn to pieces when he will reluctantly take to the water.

North of the latitude of Chicago these beautiful warblers become scarce, though to the south they breed sparingly clear to the gulf and winter in Central America.

Their food habits are entirely insectivious and worm eating, and doing no harm but much good.

CONSTITUTION AND BY-LAWS

Illinois Academy of Science

CONSTITUTION

Article I. Name

This Society shall be known as The Illinois State Academy of Science.

Article II. Objects

The objects of the Academy shall be the promotion of scientific research, the diffusion of scientific knowledge and scientific spirit, and the unification of the scientific interests of the State.

Article III. Members

The membership of the Academy shall consist of *Active Members, Non-resident Members, and Life Members.*

Active Members shall be persons who are interested in scientific work and are residents of the State of Illinois. Each active member shall pay an initiation fee of one dollar and an annual assessment of one dollar.

Non-resident Members shall be persons who have been members of the Academy but have removed from the State. Their duties and privilges shall be the same as those of active members except that they may not hold office.

Life Members shall be active or non-resident members who have paid fees to the amount of twenty dollars. They shall be free from further annual dues.

For election to any class of membership the candidate's name must be proposed by two members, be approved by a majority of the committee on membership, and receive the assent of three-fourths of the members voting.

All workers in science present at the organization meeting who sign the constitution, upon payment of their initiation fee and their annual dues for 1908, become charter members.

Article IV. Officers

The officers of the Academy shall consist of a President, a Vice-President, a Librarian, a Secretary, and a Treasurer. The chief of the Division of State Museum of the Department of Registration and Education of the state government shall be the Librarian of the Academy. All other officers shall be chosen by ballot on recommendation of a nominating committee, at an annual meeting, and shall hold office for one year or until their successors qualify.

They shall perform the duties usually pertaining to their respective offices.

It shall be one of the duties of the President to prepare an address which shall be delivered before the Academy at the annual meeting at which his term of office expires.

The Librarian shall have charge of all the books, collections, and material property belonging to the Academy.

Article V. Council

The Council shall consist of the President, Vice-President, Secretary, Treasurer, Librarian, and the president of the preceding year. To the Council shall be entrusted the management of the affairs of the Academy during the intervals between regular meetings.

The Board of State Museum Advisers, created under the provisions of the Civil Administraive Code of Illinois shall be consulted by the officers of the Academy in all matters which concern the general policy of the Academy in its relations to the Division of State Museum.

Article VI. Standing Committees

The Standing Committees of the Academy shall be a Committee on Publication and a Committee on Membership and such other committees as the Academy shall from time to time deem desirable.

The Committee on Publication shall consist of the President, the Librarian, and a third member chosen annually by the Academy.

The Committee on Membership shall consist of five members chosen annually by the Academy.

Article VII. Meetings

The regular meetings of the Academy shall be held at such time and place as the Council may designate. Special meetings may be called by the Council and shall be called upon written request of twenty members.

Article VIII. Publication

The regular publications of the Academy shall include the transactions of the Academy and such papers as are deemed suitable by the Committee on Publication.

All members shall receive gratis the current issues of the Academy.

Article IX. Affiliation

The Academy may enter into such relations of affiliation with other organizations of appropriate character as may be recommended by the Council and be ordered by a three-fourths vote of the members present at any regular meeting.

Article X. Amendments

This constitution may be amended by a three-fourths vote of the membership present at an annual meeting, provided that notice of the desired change has been sent by the Secretary to all members at least twenty days before such meeting.

BY-LAWS

I. The following shall be the regular order of business:

1. Call to order.
2. Reports of officers.
3. Reports of standing committees.
4. Election of members.
5. Reports of special committees.
6. Appointment of special committees.
7. Unfinished business.
8. New business.
9. Election of officers.
10. Program.

Adjournment.

II. No meeting of the Academy shall be held without thirty days' previous notice being sent by the Secretary to all members.

III. Fifteen members shall constitute a quorum of the Academy. A majority of the Council shall constitute a quorum of the Council.

IV. No bill against the Academy shall be paid without an order signed by the President and Secretary.

V. Members who shall allow their dues to remain unpaid for three years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

VI. The Librarian shall have charge of the distribution, sale, and exchange of the published transactions of the Academy, under such restrictions as may be imposed by the Council.

VII. The presiding officer shall at each annual meeting appoint a committee of three who shall examine and report in writing upon the account of the Treasurer.

VIII. No paper shall be entitled to a place on the program unless the manuscript or an abstract of the same shall have been previously delivered to the Secretary. Papers presented *in absentia*, shall be read by title only, unless the Academy votes to hear them.

IX. The Secretary and Treasurer shall have their expenss paid from the Treasury of the Academy while attending council meetings and annual meetings. Other members of th council may have their expenses paid while attending meetings of the council, other than those in connection with annual meetings.

X. These by-laws may be suspended by a three-fourths vote of the members present at any regular meeting.

List of Members

Life Members

(Revised December, 1919)

*Andrews, C. W., LL. D., The John Crear Library, Chicago. (Sci. Biblio.)
*Bain, Walter G., M. D., St. John's Hospital, Springfield. (Bacteriology.)
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Barnes, R. M., LL. D., Lacon. (Zoology.)
Barnes, William, M. D., Decatur. (Lepidoptera.)
*Bartow, Edward, Ph. D., State Water Survey, Urbana. (Chemistry.)
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Chamberlin, T. C., LL. D., University of Chicago, Chicago. (Geology.)
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*Crew, Henry, Ph. D., Northwestern University, Evanston. (Physics.)
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Weller, Stuart, Ph. D., University of Chicago, Chicago. (Paleontology.)
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